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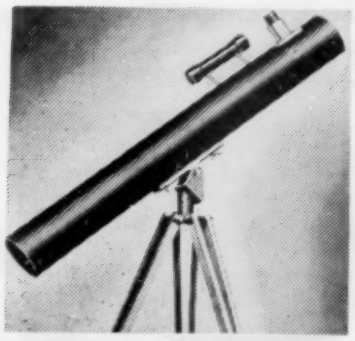

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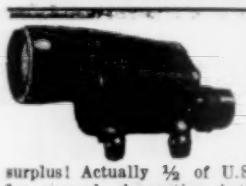

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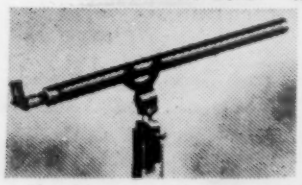

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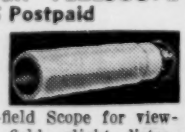

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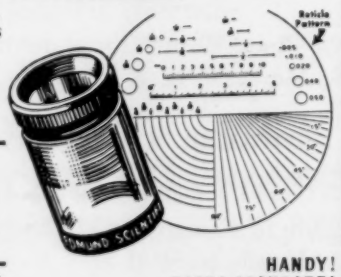

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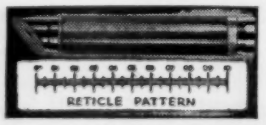

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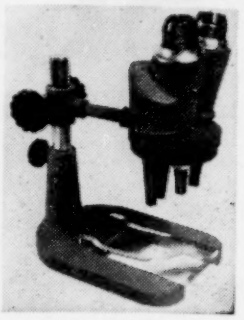

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Frequency of Usage and the Perception of Words

Mark R. Rosenzweig and Leo Postman

Telephoning in London with a poor connection, Mr. Sedgwick spells his name, identifying each letter with a word: "*S* as in 'sugar,' *E* as in 'Edward,' *D* as in 'David,' *G* as in 'George,' *W* as in 'William,' *I* as in 'Isaac,' *C* as in 'Charlie," *K* as in 'king.'" (The words he uses are suggested in "Aids toward clearness of speech" in the front of the London telephone directory.)

Monsieur Dumartin, telephoning under similar conditions in Paris, identifies the letters of his name in this way: "*D* comme 'Désiré,' *U* comme 'Ursule,' *M* comme 'Marcel,' *A* comme 'Anatole,' *R* comme 'Raoul,' *T* comme 'Thérèse,' *I* comme 'Irma,' *N* comme 'Nicolas'." (These alphabetic equivalents are in the list given in the Paris telephone directory.)

In both cases, the procedure works and the name is recognized. The alphabetic equivalents are more intelligible than the surnames or the letters. Such examples have intrigued psychologists who are interested in perception. What makes some words more intelligible than others? How should *groups* of words be chosen for maximum intelligibility? Within the past few years, several psychologists (most of them alumni of the Psycho-Acoustic Laboratory at Harvard University) have conducted studies to find what factors determine intelligibility. The results have general significance for our understanding of perception, not only in audition but in other sensory modalities as well. In fact, some of the same investigators have also studied the visual recognition of words, and comparison of results in audition and vision will help to show what is general in the perception of words and what is peculiar to one sensory modality. Studies of the perception of words have broad theoretical as well as practical interest because they illustrate some of the ways in which past experience influences perceptual discrimination.

Since 1950, three main findings have been reported. We shall list them here and then consider how they were obtained and what they imply:

1) A listener can identify words more accurately if he knows the list from which the words will be chosen. The shorter the list, the more intelligible the words will be (*1*). Evidently, then, any list of alphabetic equivalents would be an aid to intelligibility, provided only that the speaker and listener agree upon them. (How much of an aid an arbitrarily chosen list would be, we will consider later).

2) The greater the relative frequency of usage of a word in the language, the more intelligible it tends to be (*2*). Thus, in writing and speaking we use the word *age* about a hundred times more often than the word *cud,* and tests show that *age* is recognized considerably more readily than *cud.*

3) The greater the length of a word, the more intelligible it tends to be, when frequency of usage is held constant (*3*). It had been pointed out earlier that words employed in a list will be more intelligible if they cannot readily be confused with one another.

Measurement of Intelligibility

All the studies from which these results come have used the same basic technique to measure the intelligibility of words: The words are presented one by one in the presence of a masking noise, and listeners attempt to identify each word. The relative intensity of the noise to the words is varied systematically—that is, the sound intensity of the words is held constant, but the intensity of the noise is changed from one part of the experiment to another. (In some experiments, the intensity of the noise is held constant, and the intensity of the speech is varied.) The relative intensity of the noise at which listeners can just hear a word gives a measure of intelligibility, or a recognition threshold for that word. To mask some words may require 20 decibels more noise than to mask others. The importance of this difference may be gauged by noting that the noise of a pneumatic drill (or of a noisy auto) is about 20 decibels more intense than the level of ordinary conversation; these two levels are respectively about 80 and 60 decibels more intense than those of the weakest sounds that normal ears can hear. The fact that one word can be heard over the noise of a pneumatic drill while another word is just intelligible over a background of conversation does not mean that the two words differ greatly in intelligibility in the quiet. The measure tells only how well a word can overcome the effects of masking noise. It is of course precisely where there is noise—in the office, on the street, over the telephone, in the presence of other conversations—that we are concerned about intelligibility, so the measure of resistance to masking noise is a useful one.

To select words with regard to their frequency of usage in English, the Lorge magazine count (*4*) has generally been used. This is a tabulation of 4.5 million

The authors are on the staff of the department of psychology, University of California, Berkeley.

words from 1929–1938 issues of five popular American magazines. No large-scale count of *oral* usage in English is available, but the magazine-count frequencies correlate fairly highly (about 0.75) with estimates of oral usage of college students. In French, a count of oral usage has recently been completed (*5*), and we have used it in a study of intelligibility as a function of frequency in French.

Frequency of Usage

Now let us consider the results obtained when intelligibility is measured as a function of frequency of usage. The masked thresholds show that, for each tenfold increase in frequency of usage, about 4 decibels more of masking noise can be overcome. Figure 1 shows this relationship for monosyllabic English words. The most frequent words used in the experiment, shown at the right of the graph, can be heard over about 12 decibels more noise than can the least frequent words used. A similar experiment was performed with French words and French listeners, and similar results were obtained; thus the effect of frequency on intelligibility seems to be a general one.

English listeners would of course be expected to do poorly on the French list, since the frequencies of usage of French words—pronounced correctly—are near zero for English listeners. Similarly, French listeners would perform poorly on the English list. We have even found that American university students whose maternal language was not English score significantly lower on our intelligibility test than do students whose original language was English. Mr. Sedgwick and M. Dumartin clearly require separate lists of alphabetic equivalents while telephoning within their own countries. For international telephonic communication a special list of alphabetic equivalents has been worked out, a list consisting of common geographical terms whose pronunciations are reasonably similar in Western European languages.

Restriction of Alternatives

The effects of changing the length of the list of test words have also been determined experimentally. For a tenfold increase in list length, intelligibility of the words falls about 4 decibels. This indicates that a word does not have an absolute intelligibility. The listener can recognize a word more readily when it is one of two alternatives than when it is one of twenty. Thus the word is perceived in terms of the alternatives available, as the mathematical theory of information would predict. The selection of any group of alphabetic equivalents brings the length of the list to 26. Estimates indicate that, with no list available, listeners respond in terms of a set of alternatives of the order of 30,000 words. Thus an arbitrary selection of alphabetic equivalents reduces the alternatives by 1000-fold and can be expected, on the average, to improve intelligibility by about 12 decibels.

Since the selection of an arbitrary group of alphabetic equivalents would be expected to improve intelligibility, it may be asked why the names of the letters themselves are not satisfactory enough. In favor of the letter names, it could be added that many of them are homonyms of frequently used words such as *a*, *be*, and *see*. Letter names have one distinct disadvantage, however: Many of them are readily confused with each other. The confusions occur because many of the letter names have the same vowel sound, the largest group sharing one vowel sound being the nine letters *B*, *C*, *D*, *E*, *G*, *P*, *T*, *V*, and *Z*. The sound power of a word is concentrated chiefly in the vowels, while the consonants are relatively weak. Consequently, it is difficult in the presence of noise to distinguish words that differ in their consonant sounds but not in their vowels.

Length of Word

The influence of word length on intelligibility can be interpreted as a special case of the effects of length of list. When frequency is held constant, intelligibility increases steadily with word length. This beneficial effect of length is found even up to the longest words tested—words of 21 letters. In interpreting this length effect, Howes (*3*) has suggested that the listener can discriminate the length of a word even if he does not recognize the word correctly. The population from which the test word could come would thus be reduced to words of the discriminated length. If this is so, then we have once more a case where the number of alternatives has been restricted. Since there are many short words but fewer long ones, the restriction of alternatives would be greater for, say, an 11-letter word than for a 3-letter word. On the basis of relative frequencies of words of each length in the Lorge magazine count, Howes has calculated the degree to which word length might be expected to aid intelligibility, and his calculated values fit his data well.

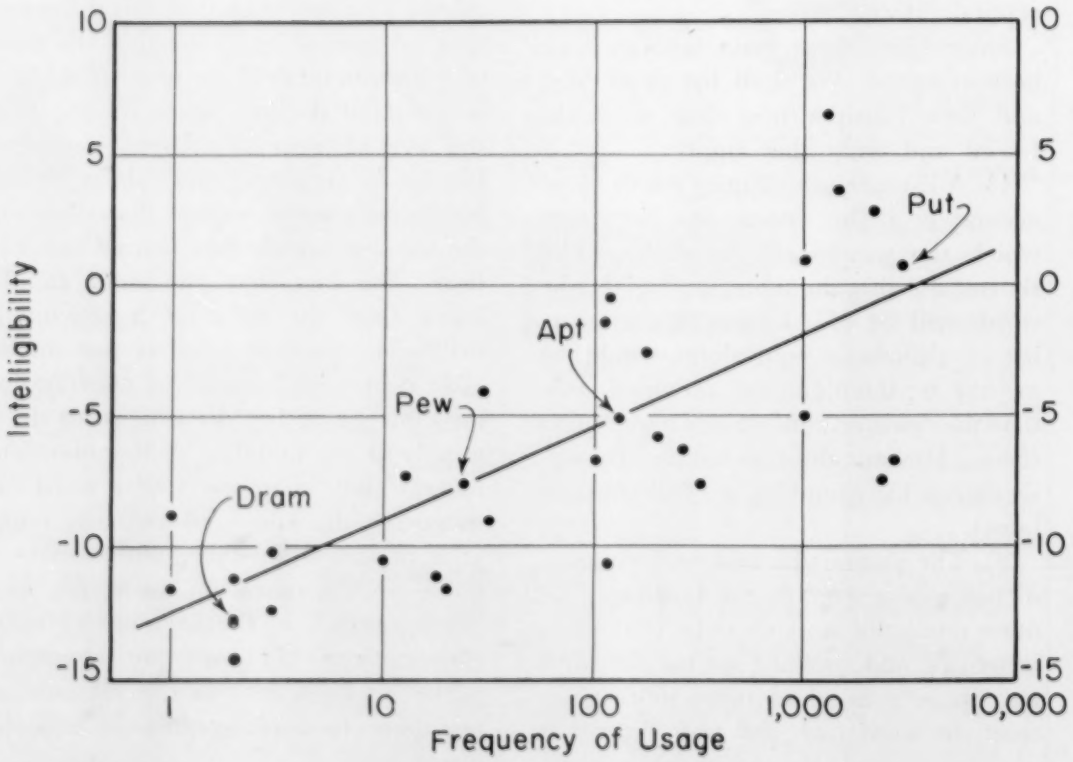

Fig. 1. Intelligibility of monosyllabic English words increases as a function of their frequency of usage. The intelligibility scale indicates the difference in decibels between the intensity of the masking noise and the intensity of the word when the word is just intelligible. Each dot represents one of the words used in the experiment, and four typical words are identified. The figure is modified from Rosenzweig (*2*).

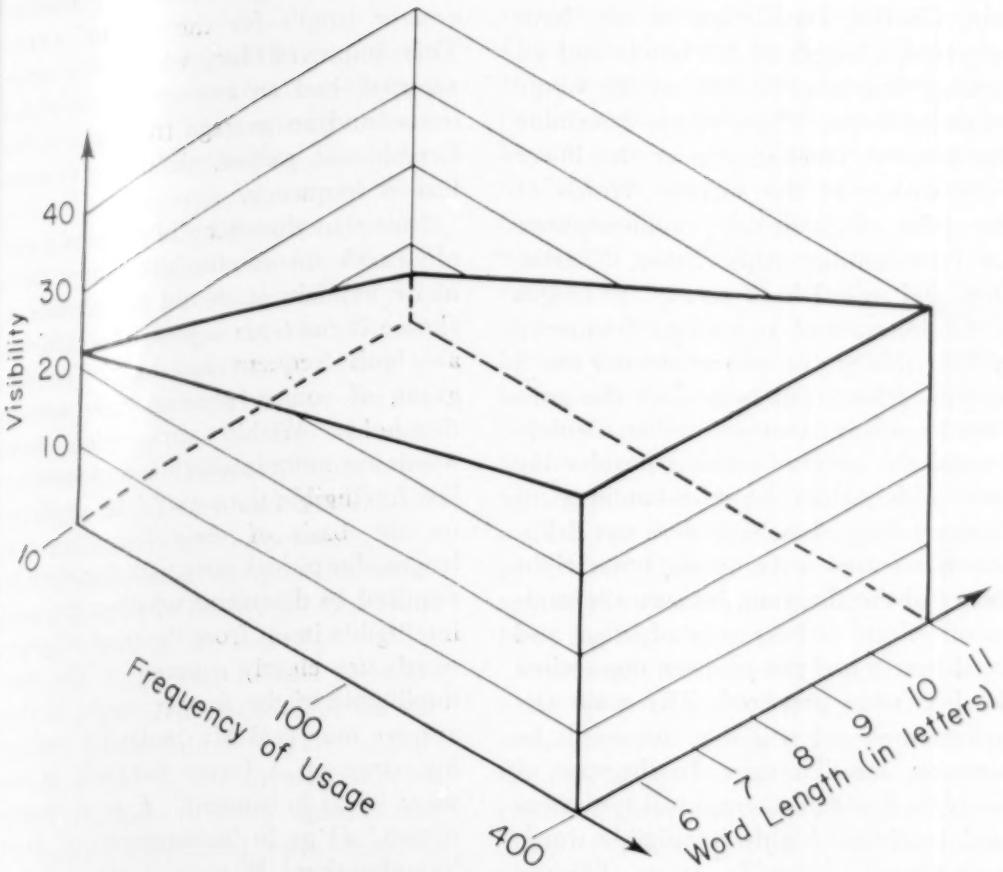

Fig. 2. A three-dimensional representation of visibility of words as a function of both frequency and word length. The sloping upper surface of the figure represents mean thresholds, greater height indicating greater visibility. The greater the frequency of the words, the less long they need be exposed to be seen, and thus the greater their visibility. Visibility decreases with word length, except for the most frequent words. (The values on the vertical scale equal 100 minus exposure duration in milliseconds.) The figure was prepared from data of Postman and Adis-Castro (*9*).

At this point a comparison of auditory and visual experiments is instructive. Experiments similar to the auditory ones have been performed with *tachistoscopic* perception of words. In this case the words are flashed on a screen for exposures of perhaps 1/100 second and the observer attempts to perceive and record them. Thresholds are determined by varying either the duration or the intensity of the flash exposure. Here, too, there is a word-frequency effect; in fact, it was discovered earlier in vision than it was in audition. The more frequently a word is used in the language, the more readily it can be seen (*6*). But in vision, contrary to the case in audition, the *longer* the word is, the *less* chance there is that the observer will report it correctly (*7*). The combined effects of frequency and word length on the visual threshold are shown in Fig. 2. The threshold is indicated by the level of the sloping surface: The higher the level, the more readily the items can be seen. The fact that greater frequency favors perception is shown by the upward slope of the surface from left to right. Length has negligible effects when word frequency is high. With words of lower frequency, greater length impairs ease of perception, as shown by the *upward* slope from back to front at the left of the figure. Figure 3 shows the effects of frequency and word length in audition. Here, too, a higher level indicates greater ease of perception. The frequency effect is similar to that in vision—the threshold surface slopes upward from left to right as frequency increases. But, contrary to the case in vision, intelligibility increases with word length—the surface slopes *downward* from back to front—for both frequent and infrequent words.

The fact that word length has opposite effects in audition and vision requires that we seek for differences between the auditory and visual cases. (Howes' formulation, as stated, would seem to be just as applicable to vision as to audition, but it clearly would not predict correctly for visual perception.) The divergent effects of word length in audition and vision may be explained partly in terms of differences in tendencies to give complete responses to auditory and visual stimuli. In two experiments, one auditory and the other visual, we employed the same list of three-letter words (*8*). The subjects had to write down words masked by noise or words flashed briefly on the screen. The thresholds for correct responses in the two sensory modalities could not, of course, be compared since one cannot measure masking noise and flash duration in the same terms. Taking only incorrect responses, we found that subjects tended to give complete, three-letter responses in the auditory case but that they tended to give incomplete one- or two-letter responses in the visual case. The responses to auditory stimuli tended to be made in units of a word or syllable; the responses to visual stimuli tended to be made in terms of letters or pairs of letters. If a perceived fragment of an auditory stimulus tends to be completed in the response, we would expect that, the longer the word, the greater the chance that the listener will perceive at least part of it and then complete the rest. In vision, however, the longer the word, the greater the chance that part of it will not be perceived and that the report will then be incomplete. It should also be noted that length is penalized by the fixed time of tachistoscopic presentation in a way that does not occur in auditory presentation. In tachistoscopic presentation, words of different length are compared at the same durations of exposure, and there is not time to shift the fixation of the eye as in ordinary reading. The greater the number of units to be discriminated during a single exposure, the more rapidly must each be discriminated. In auditory presentation, each word is pronounced at a normal rate,

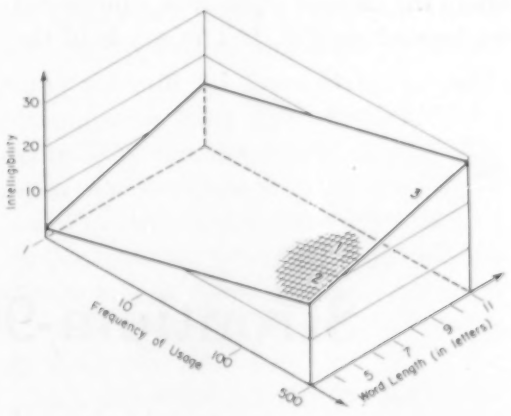

Fig. 3. Intelligibility as a function of frequency of usage and word length. The sloping upper surface represents mean thresholds. With increases in both frequency of usage and word length, words can be heard over greater intensities of masking noise. (The values on the vertical scale equal 20 plus intensity of masking noise in decibels minus intensity of the words in decibels.) The numbered locations on the surface are discussed in the final section of this article. The figure was prepared from data of Howes (*3*).

and longer words consequently are given proportionately longer presentations. The rate of discrimination then need not vary with the length of the word.

Habits and Performance Factors in the Perception of Words

Vision and audition share the beneficial effects of frequency of past usage and of restriction of alternatives upon ease of perception of words. Frequency of past usage may be considered to develop habits of responding to a particular stimulus with a particular response. The more frequently a word has been used in the past, the more readily it is recognized. The restriction of alternatives in a particular situation operates differently. It does not change the perceiver's habits, which are based on his history of past usage. Rather it is a "performance factor" which influences the use made of already formed habits. The smaller the number of alternatives included in the set of words expected by the perceiver, the more ready he can be to use each of the corresponding habits. Thus both frequency of usage and restriction of alternatives make it easier to give a complete response to a stimulus word on the basis of fragmentary discriminations.

A Practical Suggestion

Our survey of the factors governing intelligibility suggests a way in which more highly intelligible alphabetic equivalents might be selected. First let us see where the current alphabetic equivalents are located on Fig. 3. The words of the English telephone list (Andrew, Benjamin, Charlie, David, and so on) have an average length of 5.7 letters and an average frequency of 254 on the Lorge magazine count. These values determine the location labelled *1* near the lower right corner of the surface. Words of the joint U.S.–British radiotelephone list (the familiar Able, Baker, Charlie, Dog, and so on) have an average length of 4.1 letters and an average frequency of 355; this group centers around the 2 on the surface. (In both cases the individual words scatter rather widely around the average values, considerably more widely than the cross-hatching indicates.) Now these lists were not deliberately selected to be on the lower right corner of the diagram, because the studies on effects of frequency of usage and word length had not yet been done when the lists were prepared. The main criterion employed was that the words be common, familiar ones. In the case of the U.S.–British list, empirical tests were used to choose highly intelligible words from a pool of familiar items. The use of the criterion of familiarity leads to words of high frequency and low length, since familiarity implies high frequency and since, in turn, frequent words tend to be short. It should be noted, however, that although frequently used words tend to be short, there are many frequent words of considerable length. The figure indicates that by selecting longer words toward the upper right corner of the surface, the region labelled *3*, a gain of over 6 decibels in resistance to noise might be achieved. In fact, wartime tests of intelligibility demonstrated that many of the items of the U.S.–British list could be improved. Twenty-two changes were suggested on the basis of empirical tests; 19 of the changes substituted items of greater length for the original words. This improved list, which was never adopted, had an average length of 6.4 letters and an average frequency of 56. Length was gained, though with some loss in frequency.

Now that the effects of frequency and of length on intelligibility have been made explicit, it should be possible to choose items from a pool of words that are both frequent and long. The diagram, of course, presents only average thresholds. Within any region, some words are more intelligible and some are less intelligible than would be predicted on the basis of their frequency and length. Empirical tests will therefore be required to determine whether the most intelligible items from the pool of longer words are clearly superior to the most intelligible of the shorter words. If they are, we may find Mr. Sedgwick spelling his name on a future occasion in this way: "*S* as in 'student,' *E* as in 'examination,' *D* as in 'department,' *G* as in 'grandmother,' *W* as in 'welcome,' *I* as in 'industry,' *C* as in 'companion,' *K* as in 'kindness.' "

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Strontium-90 in Man, II

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The continuation of nuclear tests makes a thorough understanding of the movement and uptake of strontium-90 a necessity while the levels in man and his environment are still relatively small compared with natural background radiation. In a previous publication (*1*) the first data on a world-wide analysis of strontium-90 in human tissue were presented. The study of the geochemical distribution of strontium-90, of its transfer through the food chain, and of its variation in human populations has continued (*2*). This article (*3*) summarizes over a thousand analyses of human bone and interprets these data in terms of present concentrations of strontium-90 in the various critical phases of the geosphere and biosphere. The new data permit a closer definition of the average concentration of strontium-90 in a large part of the human race, the geographical and dietary variation, the increase in the concentration with time, and the distribution in urban populations. From the existing data, an attempt is made to predict future levels under specified conditions.

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Experimental Data

The methods employed for the radiochemical separation of strontium-90 from human bone and the low-level radiometry have been described in detail elsewhere (*4*). The vegetable samples are treated in essentially the same way after dry ashing, although a strontium-85 spike is introduced in each sample for yield determination because of the variable character of the material. The bone assays were done at the Lamont Geological Observatory and at two commercial laboratories: Isotopes Incorporated, Westwood, New Jersey, and Nuclear Science and Engineering Corporation, Pittsburgh, Pennsylvania. Frequent intercalibrations assured reliability of the results from the different laboratories.

Autopsy samples of human bone are now being received from about 30 stations in a world-wide network (*5*). During this period of the investigation an attempt was made to obtain samples that were equally distributed with regard to the age of the individual at death. An attempt was also made to obtain maximum spread in geographic and dietary setting, but the restriction in the location of medical centers has limited the samples largely to urban populations.

The results reported in this article include those given in the previous report with the exception of samples which contained less than 1.0 gram of calcium. Very small samples are subject to large statistical errors and are more sensitive to slight contamination. The elimination of such samples at an arbitrary calcium level does not cause preferential selection of the data, reduces the number of samples by less than 5 percent, and does not seriously affect the final averages. Currently, only samples containing more than 1.0 gram of calcium are assayed for strontium-90. Also omitted are data reported in the previous article for the 49-year-old Vancouver (British Columbia) female (died October 1955; 8.3 micromicrocuries of strontium-90 per gram of calcium) and for the 34-year-old Japanese man (died June 1955; 4.05 micromicrocuries of strontium-90 per gram of calcium). Each of these two results is greater than the mean value for adults in 1955 by a factor of 50 to 100 and larger than the next nearest adult value by a factor of 5 to 10. They may be real but rare high values. On the other hand, there are cogent reasons for rejecting them as artifacts: (i) Clinical data indicate that the individuals were city dwellers. Data on urban foods make it extremely unlikely that these adults had a sustained diet of 100 times the average strontium-90 concentration. (ii) These samples now lie about 100 standard deviations from the mean (see discussion later in this article on the distribution curve). (iii) These were among the first few batches of samples analyzed commercially. (iv) When the medical history of the Vancouver patient was checked, it was found that she had carried a radium seed. Although this last finding should not affect the strontium-90 analysis if the analysis is properly done, it presents a possible explanation of the high value, particularly since the analysis was made in the early phase of the work. Even if these two anomalous samples were included, this would not affect any of the conclusions which are drawn from the regional averages.

All results are reported in micromicrocuries of strontium-90 per gram of calcium. Samples which were reported by the analysts as "equal to or less than" a certain number are assumed to have that value (that is, "≤ 0.02" is taken as 0.02) in computing the averages. Therefore, the reported averages are maximal. If all such samples are eliminated it would change the general averages by less than 10 percent but would reduce the total number of samples by about one-quarter.

These measurements have been made in an attempt to determine the average concentration of strontium-90 in the whole skeleton of a man. In the world-wide sampling, however, only a single bone is obtained, generally either vertebrae, rib, or femur shaft. Although stable-strontium/stable-calcium ratios are essentially constant among the bones of the skeleton, experiments conducted by Schulert and Laszlo (*6*), in which single intravenous doses of calcium-45 and strontium-85 were given to ten patients, followed by analyses at death (1 to 125 days after administration), show large but consistent differences in the amount of strontium-85 per gram of calcium. The stable element result reflects long-term continuous ingestion on a near-constant diet of stable-strontium/stable-calcium. The tracer experiment shows the maximum differences to be expected in the adult skeleton for a dose of radioisotope over a short time interval. Since the bones of adults are not in equilibrium with the strontium-90 in the diet and since there is a long turnover time for mature bone, the strontium-90 concentrations in the various bones of the skeleton should also be different. Therefore it is necessary to define the normalization factors that are required to convert the analytical data on single bones to average strontium-90 concentrations for the whole skeleton.

Table 1. Normalization factors from single bone to average skeleton (adults).

Sr^{85} single dose in man		Sr^{90} distribution in 10 New York cadavers* (*7*)
Previous estimate (*1*) 1 case	Present estimate (*6*) 10 cases*	
	Vertebrae	
4.2	4.8	3.4
	Rib	
2.0	2.1	1.5
	Long bone shaft	
0.7	0.6	0.8

* The standard deviation is about ± 25 percent of the value.

Table 1 gives these normalization factors for the strontium-85 single-dose experiments and for natural strontium-90 in ten cadavers from New York (*7*). The distribution of strontium-90 is more uniform than that in the extreme case of the single strontium-85 dose, but it shows significant differences with respect to the various bones of the skeleton. The strontium-90 factors, rather than those for the strontium-85 experiments, have been used in correcting all individual measurements to the whole-skeleton value for all samples from individuals 20 years of age and older.

In individuals of from 0 to 19 years of age, the strontium-90 distribution is more nearly uniform, since most of the strontium-90 has been introduced into the skeleton by bone growth rather than by exchange and remodeling, as is the case with adults; hence, no correction has been made. Clearly, however, this is only an approximation, since children's bones are still far from being in equilibrium with their diet. Empirical evidence that this treatment of the data more nearly reflects the true situation is found in the consistency of the data, in similar latitudes, for adults and children, represented by different bones. Samples are now being obtained to verify this point directly.

For convenience, the time intervals chosen to show the progressive increase in concentration of strontium-90 begin on 1 July of each year. The impact of the major nuclear tests of the spring of 1954 did not begin to show up in human bone until after 1 July of that year. The present discussion covers the period from 1 July 1953 to 30 June 1957.

The analytical errors on the individual measurements range from 2 to 50 percent, depending on the activity, but most

Table 2. Average strontium-90 content in man, 1 July 1955 to 30 June 1956 and 1 July 1956 to 30 June 1957. All values are given in micromicrocuries of strontium per gram of calcium, normalized to the whole skeleton. The figures in parentheses give the number of samples in the category.

Location	Age at death (yr)								
	0–4	5–9	10–19	20–29	30–39	40–49	50–59	60–80	20–80 (average)
					1955–56				
North America	0.56(10)	0.44(4)	0.20(13)	0.09(34)	0.07(38)	0.06(14)	0.04(17)	0.07(34)	0.070(137)
South America	0.33(12)	0.19(16)	0.14(26)	0.07(48)	0.06(58)	0.08(45)	0.07(18)	0.11(15)	0.073(184)
Europe	0.42(30)	0.27(19)	0.23(46)	0.06(70)	0.10(59)	0.06(8)	0.16(1)	0.09(3)	0.078(140)
Asia		0.10(2)	0.20(9)	0.06(35)	0.07(32)	0.11(11)	0.13(13)	0.20(4)	0.085(95)
Entire world	0.43(52)	0.25(41)	0.20(94)	0.068(187)	0.076(187)	0.079(78)	0.077(49)	0.091(56)	0.076(556)
	World average 1955–56 = 0.15								
					1956–57				
North America	0.67(30)	0.69(17)	0.38(15)	0.07(14)	0.06(9)	0.08(16)	0.05(5)	0.07(18)	0.070(62)
South America	0.16(3)	0.20(1)	0.19(5)	0.03(5)	0.02(2)	0.03(2)	0.06(3)	0.01(1)	0.034(13)
Europe	0.65(2)	0.34(4)	0.34(9)	0.06(20)	0.07(4)	0.04(6)	0.06(1)	0.08(2)	0.059(33)
Africa			0.06(2)	0.03(2)	0.03(3)	0.04(4)			0.035(9)
Asia	0.93(1)	0.12(2)	0.32(2)	0.06(8)	0.04(6)	0.12(8)	0.06(5)	0.05(5)	0.070(32)
Australia	0.75(3)	0.60(2)			0.03(3)	0.03(4)	0.03(3)		0.030(10)
Entire world	0.64(39)	0.57(26)	0.30(33)	0.059(49)	0.047(27)	0.070(40)	0.052(17)	0.065(26)	0.060(159)
	World average 1956–57 = 0.20								

samples have an error of the order of 5 to 10 percent. In general, the analytical error is quite small compared with the degree of uncertainty about the relation of an individual bone to the whole skeleton. Variations in the strontium-90 concentration within a given bone and among similar bones of the same individual show a standard deviation of about ±25 percent. Since this effect should average out in a large number of samples, the uncertainty in the national or global averages is probably controlled by variation in local fallout and diet rather than by variability in sampling procedure.

Regional Averages and Age Dependence

The strontium-90 content of the average human bone for each continent, as a function of age, for 1955–56 and 1956–57 is given in Table 2. It is evident that there is no significant difference in the age groups of 20 years and older. The differences from one 10-year age group of adults to another at the same station do not exceed the mean by more than about 10 percent for those cases where a large number of samples is available. Therefore, the adult samples may be pooled for statistical purposes. The ratio of the strontium-90 level in young children (0 to 4 years) to that in adults rises from about 6 to 1 in 1955–56 to 10 to 1 in 1956–57, reflecting the more rapid approach to equilibrium of the children due to the growth of new bone. It is noted that in 1956–57 the highest values are found in North America, while values for South America, Africa, and Australia are about half of this, with those for Europe in between. For all samples, the value for the average female is about 15 percent higher than that for the average male. Since the data include a thousand individuals nearly equally divided with respect to sex, this result is considered significant.

The "world averages" were computed by weighting the average for each age group by the fraction of the world population in that age group. The Asian samples come only from Japan, Taiwan, and India. But if Taiwan can be presumed to represent Southeast China, a large fraction of the people in Asia are included. The levels in Russia are very probably higher, due to the proximity to test sites. Since the differences in the average bone level from one station to another seldom exceed a factor of two, the calculated "world average" is relatively insensitive to the distribution of the sample location. Finally, the stations in the United States, Europe, Japan, China, and India may represent 70 to 80 percent of the world's population.

Table 3 shows that the strontium-90 level in human beings is more uniform than the total fallout. One reason for this, as suggested to us by Lyle Alexander, of the U.S. Department of Agriculture, is the widespread distribution of milk products from the United States and northern European countries.

The world-wide average for the urban world population in 1955–56 is seen to be about 0.15 micromicrocuries of strontium-90 per gram of calcium, which represents a level of about 0.076 in adults and 0.43 in young children. In 1956–57 these figures are 0.20, 0.060 and 0.64, respectively, showing an increase in the young children of 50 percent and in the world average, of about 30 percent.

Individual Stations and Time Effect

Table 4 lists the average values for children aged 0 to 4 and 5 to 9 and for adults, as a function of time, in the stations from which analyses have been completed. Significant comparison of certain localities can be made only if the samples are numerous, because of the individual biological variation. Values

Table 3. Comparison of variations, with latitude, in strontium-90 content of human bone and in total fallout.

Latitude	Human bone (Av. for 1955–57) ($\mu\mu$c Sr^{90}/g Ca)		Soil, (June 1956)* (mc/mi^2)
	Age at death		
	0–4	Adults	
60–40°N	0.55	0.07	~8
40–20°N	0.68	0.085	9.4
20–0°N	0.32	0.075	3.9
0–20°S		0.05	2.0
20–40°S	0.46	0.06	2.6

* From remarks prepared by Merril Eisenbud, manager of the New York Operations Office, U.S. Atomic Energy Commission, for hearings of the Joint Committee on Atomic Energy, 27 May 1957.

Table 4. Average strontium-90 concentration in man for three periods (1 July 1954 to 30 June 1955; 1 July 1955 to 30 June 1956; 1 July 1956 to 30 June 1957) for each station. All values are given in micromicrocuries of strontium-90 per gram of calcium, normalized to the whole skeleton. "Adult" represents samples of individuals who died at 20 years or older. The figures in parentheses indicate the number of samples in the category.

Location	Bone	1954–55			1955–56			1956–57		
		Age at death (yr)			Age at death (yr)			Age at death (yr)		
		0–4	5–9	Adult	0–4	5–9	Adult	0–4	5–9	Adult
Boston	Vertebrae	0.78(2)			0.61(3)	0.22(1)		0.69(25)	0.71(15)	0.06(19)*
New York	Mixed	0.17(1)		0.05(44)			0.05(38)			
Denver	Vertebrae	0.29(3)			0.48(4)	0.1(1)	0.08(44)	0.67(3)	0.59(1)	0.06(6)
Houston	Mixed	0.32(2)		0.15(23)	0.82(3)		0.14(11)			
Vancouver	Tibia	0.32(2)	0.07(2)	0.08(16)			0.05(29)	0.42(2)	0.72(2)	0.08(21)
Puerto Rico	Vertebrae			0.08(15)	0.27(2)		0.07(16)		0.48(1)	
Venezuela	Rib		< 0.17(1)		0.33(12)	0.34(8)	0.09(51)			
Colombia	Rib → Vertebrae			0.09(2)			0.04(7)			0.02(2)
Argentina	Vertebrae									0.05(2)
Chile	Rib		0.19(3)	0.10(13)		0.04(8)	0.07(86)	0.16(3)	0.20(1)	0.03(9)
Brazil	Rib		0.07(1)	0.10(4)			0.05(41)			
Australia	Rib							0.75(3)	0.60(2)	0.03(10)
Taiwan	Mixed	0.2(1)		0.03(2)		0.14(1)	0.08(18)	0.93(1)	0.09(1)	0.04(4)
India	Rib		0.32(2)	0.10(6)		0.06(1)	0.07(58)			0.08(11)
Japan	Rib						0.14(19)		0.14(1)	0.08(15)
Iran	Femur									0.03(2)
Denmark	Vertebrae	0.18(1)	0.20(1)	0.03(2)		0.22(1)	0.05(12)		0.36(1)	0.04(7)
England	Vertebrae				0.74(5)	0.18(6)	0.04(14)	0.31(1)		0.06(11)
Germany	Femur	0.31(3)	0.10(2)	0.11(12)	0.30(20)	0.18(6)	0.08(79)			0.05(11)
Italy	Rib			0.09(4)	0.37(1)		0.13(14)			
France	Rib						0.05(5)			
Switzerland	Vertebrae	0.53(3)		0.09(5)	0.60(4)	0.47(6)	0.09(17)	0.98(1)	0.44(2)	0.09(10)
Union of So. Africa	Rib									0.04(11)

* Femur

for Houston, Texas, appear to be significantly higher than those for other North American cities for 1954–56. Values for adults in Chile, South Africa, and Australia are lower than those for adults in Northern Hemisphere stations by a factor of two. It is noted that the adults show a small apparent decrease in strontium-90 content during the past year. This is primarily due to the variation in stations represented in the two years (for example, the bones of individuals in Houston, which had higher-than-average values in 1954–56, are not represented in 1956–57). The results do show that the rise in children is much greater than that in adults. This is a striking reflection of the fact that, whereas adults are merely exchanging a small fraction of their skeleton each year, the children are building new bone in equilibrium with their diet, in addition to exchange.

Comparative strontium-90 data for England have been obtained by Bryant *et al.* (*8*) from a dozen localities. For 1955–56 their data show an average of 0.77 micromicrocuries of strontium-90 per gram of calcium in 18 samples, 0.22 micromicrocuries of strontium-90 per gram of calcium in 3 samples, and 0.08 micromicrocuries of strontium-90 per gram of calcium in 19 samples for the 0 to 4, 5 to 9, and adult age groups, respectively. The averages agree with those reported in Table 4, within the standard deviation of each, and they are as high as those of any comparable area in North America. The higher average rainfall in the British Isles apparently compensates for the greater distance from the Nevada test site. In addition, westward-moving Russian tropospheric debris would presumably contribute more fallout to Great Britain than to the United States.

Table 5 compares the change in levels of strontium-90, with time, for cumulative New York rainout, New York and Wisconsin milk, bones of young children (age 0 to 4) and of adults in northeastern United States, and bones of young children from North American stations. These sets of bones were taken because they represent the largest number from one area or continent over the period of interest. The values for milk and for the cumulative fallout go up proportionally, whereas those for bones lag behind, due

Table 5. Increase in strontium-90 levels in various materials. The figures in parentheses represent the number of samples in the category.

Sample	Units	1953–54	1954–55	1955–56	1956–57
Cumulative rainout (New York)*	mc/mi²	5	9	18	28
Milk (New York)†	μμc Sr^{90}/g Ca	0.8	1.25	2.4	3.5
Milk (Wisconsin)†	μμc Sr^{90}/g Ca	1.2	2.0	3.0	4.3
Bones of children (0 to 4 yr) (New York and Boston)	μμc Sr^{90}/g Ca	0.28(5)‡	0.57(3)	0.61(3)	0.69(25)
Bones of children (0 to 4 yr) (North America)	μμc Sr^{90}/g Ca	0.28(5)‡	0.38(10)	0.56(10)	0.67(30)
Bones of adults (New York and Boston)	μμc Sr^{90}/g Ca	0.02(3)‡	0.05(44)	0.05(38)	0.06(19)

* Data from New York Operations Office of U.S. Atomic Energy Commission and Lamont Geological Observatory.
† Data from New York Operations Office interpolated from reports (*10*).
‡ Data of Libby (*12*).

to the delay in reaching equilibrium with the diet. Thus, although the fallout and milk samples increased three-and-one-half- to sixfold from the end of 1953 to the end of 1956, the bone levels increased two- to threefold.

Distribution in Single Population Group

In order to predict the fraction of the human population that will have any given concentration of strontium-90, it is necessary to examine the statistical distribution of strontium-90 in certain well-defined groups. Consider first only people living in cities or those who obtain their food from central distribution centers. The greatest spread will be obtained by grouping together adults of all ages from all localities. Figure 1 is a histogram showing the distribution of all adult samples in 1955–56. There are a number of factors which tend to make the distribution for adult groups, even at one site, much larger than will actually be the case at equilibrium. These include biological variation from one bone to another in a single individual and the different rates at which individuals equilibrate their bones with their diet. Thus, a histogram of adult samples would be considerably skewed to the right. Such a distribution will probably become narrower as equilibration proceeds. The group in which the equilibrium situation is likely to be most closely approximated is that of young children (Fig. 1), who have strontium-90 more uniformly distributed in their bones. Thus, although the distribution curve for all adults in 1955–56 shows a log normal form with a standard deviation of about 100 percent and with one case out of 557 having a value seven times the mean, the young children from Boston and Switzerland more closely approximate a Gaussian-type distribution, with a standard deviation of about 40 percent. Since even these children are not at equilibrium, it is expected that the distribution will become still narrower. For urban populations the distribution at equilibrium may approach a normal Gaussian distribution, but it is expected that the world-wide distribution will always be skewed somewhat toward higher values since, locally, it is possible to increase the amount of strontium-90 per gram of calcium in the soil, and therefore in foods, by factors of 100 to 1000 times the urban mean but to decrease it by factors of only 2 to 10. Present experience in attempting to locate such high values suggests that they will represent a very small fraction of the world population.

From the limited number of samples near equilibrium at any given location it is difficult to estimate the ultimate situation with precision. Nevertheless, it does appear that the bulk of the world's population can be described roughly by a Gaussian distribution with a standard deviation of about 40 percent. Thus, at equilibrium, 99 percent of the people will probably be within about twice, or half of, the mean. Data are simply not available to estimate the distribution in nonurban segments of the population, but it is probably less uniform.

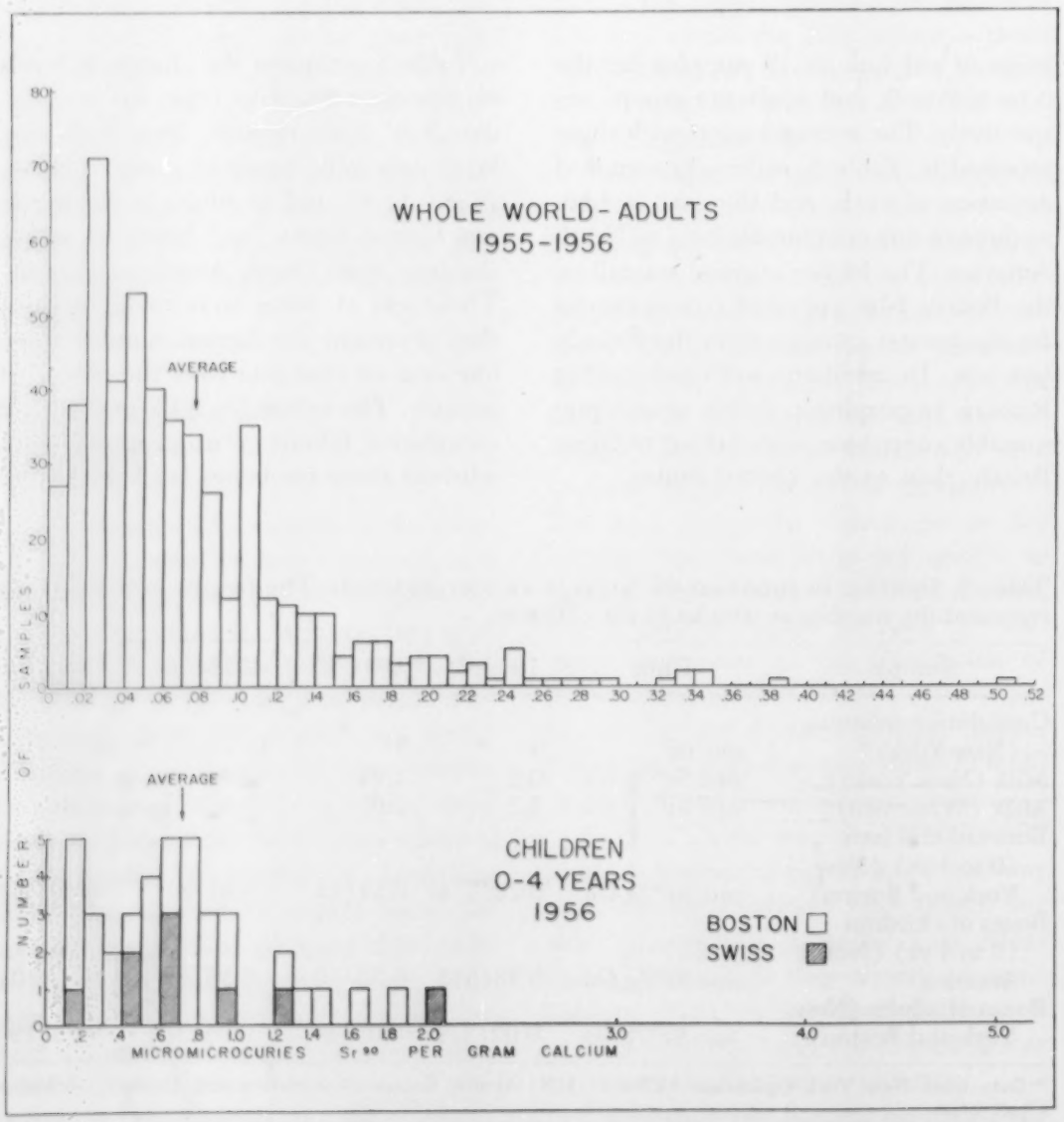

Fig. 1. Histogram of strontium-90 concentration in the bones of adults and children.

Bone Level and Diet

If the amount of strontium-90 per gram of calcium can be defined in the diet of a population group, and if the discrimination factors between diet and bone are known for strontium-to-calcium, the equilibrium level of strontium-90 in the whole skeleton can be predicted. In determining the contribution of strontium-90 to the bone from the diet of any individual it is necessary to know the calcium content, the strontium-90-per-gram-of-calcium ratio for each ingredient, and the strontium-calcium fractionation factors along the food chain. Table 6 gives the relative contribution of calcium by various foods in most national diets (*9*). It is evident that, for a large portion of the world, milk products are the dominant source of calcium. Fish carry very low specific activity of strontum-90, due to the dilution in the large reservoir of ocean calcium. Meat and eggs contribute a negligible amount. Table 7 gives data on the concentration of strontium-90 in milk from various parts of the world, obtained by the New York Operations Office of the U.S. Atomic Energy Commission (*10*) and by the British workers (*11*), for 1956. Table 8 gives new experimental measurements on the concentration of strontium-90 in frozen foods in the United States. Presumably, canned vegetables will show a similar average, but the making of measurements on this important food source is only beginning.

Table 6. Sources of calcium in national diets (in percentage of contribution to total calcium in the diet).

Country	Cereals	Potatoes and starchy roots	Pulses and nuts	Meats	Eggs	Fish	Milk and dairy products
Austria	6	6	1	1	1		85
Belgium–Luxembourg	8	11	1.5	1.5	2	1	75
Denmark	6	9	2	2	1	1	79
Finland	6	7		1	1	1	84
France	8	10	2	2	2	1	75
Germany (West)	7	14	1	1	2	1	74
Greece	17	5	12	1	1	1	63
Ireland	8	12	1	2	2		75
Italy	19	6	8	1	3	1	62
Netherlands	6	7	1	1	1	1	83
Norway	5	5	1	1	1	1	86
Portugal	26	26	9	1	2	6	30
Sweden	4	5	1	1	1	2	87
Switzerland	5	4	2	1	1		87
United Kingdom	6	7	2	2	2	1	81
Yugoslavia	20	6	5	1	1		67
Canada	4	4	2	2	3		85
United States	4	3	2	2	4	1	85
Argentina	9	5	1	3	2		79
Chile	15	7	5	2	2	2	67
Cuba	12	11	10	2	1	1	64
Peru	17	29	8	2	2	1	41
Uruguay	8	5	1	3	2		82
Venezuela	9	5	8	1	1	1	75
India	24	2	2				51
Pakistan	22	1	1				72
Israel	15	3	4	1	3	2	73
Japan	46	17	8		3	8	18
Philippines	39	15	18	2	3	5	18
Egypt	30	2	9	1	1	1	57
Rhodesia	36	2	14	5	1	1	41
Turkey	38	7	14	2	1	1	37
Union So. Africa	21	3	2	2	1	1	71
Australia	7	4	2	3	2		82
New Zealand	5	2	1	2	2	1	88

The data on cereals are also meager as yet, but the indication is that the figures are higher than those for milk of the same region by a factor of about 6 (*12, 13*). The extent of calcium-strontium discrimination in the transfer from diet to human bone is still debated, although the divergence of opinion has decreased. The previously suggested value of eight (*1*) now appears high. Comar (*14*) has estimated that the factor is about two. However, the work of Spencer, Laszlo, and Brothers (*15*) and of Schulert *et al.* (*6*) suggests a value of about four, and this value has been used in the subsequent calculations.

When one knows the average diet and the strontium-90 content of foods, the relative importance of the various components of the diet can be estimated. In 1956–57 in the northeastern United States, for example, the level in milk was about 3.5 micromicrocuries of strontium-90 per gram of calcium, the vegetable intake was about 7.3 (Table 8), and the level for cereals was estimated at about 20. Therefore, the equilibrium concentration of strontium-90 in the bone for this dietary composition, when the discrimination factor of four and the data of Table 6 are used, is computed to be 1.1 micromicrocurie of strontium-90 per gram of calcium which is dominated by the milk level.

From the diet data and the discrimination factor, the strontium-90/calcium ratio which will occur in the newly deposited bone of children can be calculated. Langham and Anderson (*16*) first suggested this approach and used it to compute the fraction of equilibrium for skeletons of any given age group. The data for bone indicate that for adults the total integrated exchange and remodeling amount to about 7 percent of the equilibrium value if the discrimination factor of four is assumed. In predicting the strontium-90 level in children it is assumed that, in addition to growth, they have the same percentage of exchange and remodeling as adults. Other assumptions and data on which the calculation is based are as follows: (i) The New York milk levels are taken from Table 5 and are assumed to be representative of the northeastern United States. (ii) The relative contribution to the calcium content of the diet from milk and vegetation for this period is given in Table 6. (iii) The yearly accretion of skeletal calcium in males is given by Mitchell *et al.* (*17*). (iv) The discrimination between strontium and calcium in transfer from diet to bone is four. (v) The fetal protective factor is two (*18*).

The calculation yields the solid curve shown in Fig. 2. The dotted curve is computed in an identical manner, but a discrimination factor from food to bone of two instead of four is assumed. Also plotted are the experimental data from the United States and Europe, which closely approximate the theoretical curve for a discrimination of four.

The concentration of strontium-90 in adults suggests that only 1 to 2 percent of bone is exchanged or remodeled per year.

On the basis of these relationships, the equilibrium levels in human bones are computed for the end of 1956 for all continents. The results are given in Table 9. It is clear that the equilibrium level for the Southern Hemisphere will be about one-half that for the Northern Hemisphere.

Future Levels

The concentration of strontium-90 in human bone at any future time for any specified kind and amount of testing can now be predicted within certain limits. The greatest area of uncertainty is that which pertains to the stratospheric reservoir. Although there are a number of ways of attacking this problem, we will start with the actual levels in bone. The

Table 7. Strontium-90 in milk at various locations, 1956. [Data from New York Operations Office and British workers (*10, 11*).]

Location	Amount ($\mu\mu$c Sr^{90}/g Ca)
Perry, N.Y.	3.3
State College, Miss.	5.3
Columbus, Wis.	3.4
Mandan, N.D.	8.8
Portland, Ore.	5.5
Japan	2.8
United Kingdom	4.5
Somerset, England	4.2
Other areas in England	6.9

results are summarized in Table 10, along with other comparative data.

There may be as much as a half-year lag between fallout and its effect on the strontium-90 level in vegetation, but this interval is short when compared with the other factors involved; so it will be assumed that diet level and integrated total fallout level are essentially in equilibrium. The predicted equilibrium value for the average population (1.1 micromicrocuries of strontium-90 per gram of calcium in North America), calculated on the basis of fallout through the end of 1956 and on the correlation of the actual bone data with the predicted population levels as a function of age shown in Fig. 2, appears to be fairly well defined. (Actually, if no more strontium-90 were deposited on the ground after 1956, this hypothetical equilibrium level would not be attained, since the concentration of strontium-90 in the reservoir would be reduced continuously by radioactive decay.)

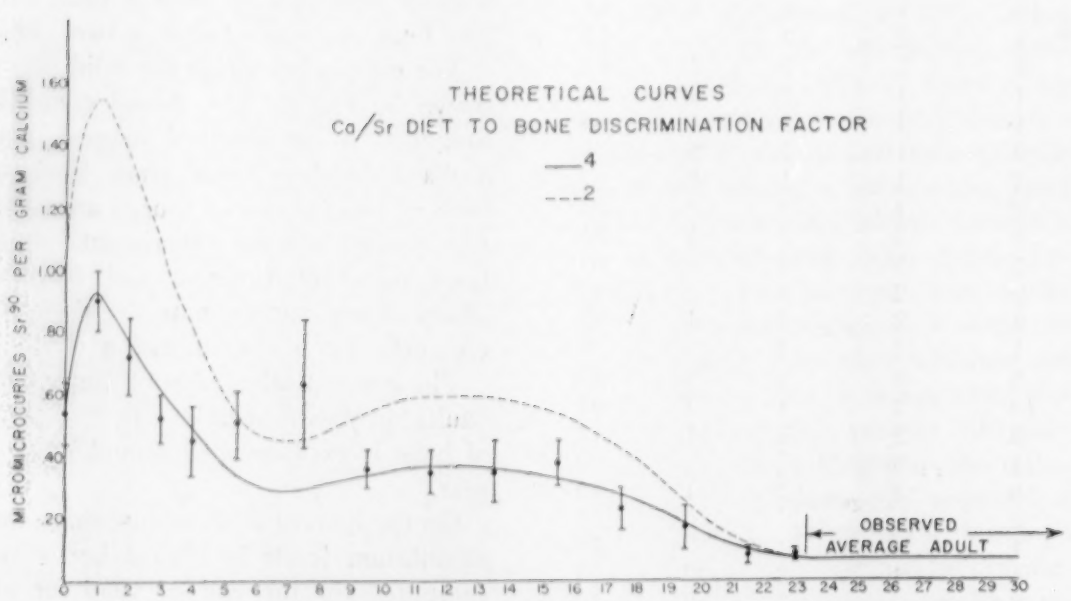

Fig. 2. Comparison of the experimental data on the concentration of strontium-90 in man as a function of age with the theoretical curves obtained from the dietary level of the northeastern United States from 1952 to 1957 and discrimination factors between diet and skeleton of four and two.

Table 8. Concentration of strontium-90 per gram of calcium in common frozen vegetables (1956) (Lamont Geological Observatory data).

Date of harvest	Vegetable	State	Concentration ($\mu\mu$c Sr^{90}/g Ca)
Sept. 1955	Lima beans	Idaho	6.3 ± 0.3
Sept. 1955	Lima beans	California	10.0 ± 0.4
Early 1956	Lima beans	Delaware	2.9 ± 0.2
Early 1956	Cauliflower	?	2.7 ± 0.3
1955–56	Corn	?	3.6 ± 0.2
1955–56	Peas	?	1.3 ± 0.3
Early 1956	Spinach	Tennessee	6.1 ± 0.1
Feb. 1956	Turnip greens	Tennessee	7.8 ± 0.1
June 1956	Asparagus	Maryland	1.7 ± 0.2
June 1956	Peas	Minnesota	5.8 ± 0.2
July 1956	Peas	Washington	7.8 ± 0.3
Aug. 1956	Peas	Maine	21.3 ± 0.6
Aug. 1956	Cut green beans	New York	20.2 ± 0.5
Sept. 1956	Corn	Minnesota	1.6 ± 0.3
Sept. 1956	Squash	Oregon	3.1 ± 0.2
Sept. 1956	Brussels sprouts	California	4.3 ± 0.2
Sept. 1956	Cut green beans	Pennsylvania	4.6 ± 0.3
Sept. 1956	Cut green beans	Pennsylvania	8.0 ± 0.4
Sept. 1956	Lima beans	Delaware	8.4 ± 0.2
Fall 1956	Cauliflower	New York	8.1 ± 0.3
Fall 1956	Spinach	California	11.5 ± 0.3
Oct. 1956	Asparagus	Maryland	1.7 ± 0.2
Oct. 1956	Broccoli	Maryland	4.7 ± 0.1
Oct. 1956	Broccoli	Maryland	6.7 ± 0.3
Oct. 1956	Broccoli	Maryland	8.5 ± 0.3
Oct. 1956	Brussels sprouts	California	12.0 ± 0.3
Oct. 1956	Cauliflower	New York	9.1 ± 1.3
Mar. 1957	Spinach	California	13.9 ± 0.2
		Average	7.3

Prediction of future levels involves knowledge of the stratospheric reservoir. Libby (*19*) has estimated the mean residence time of the stratospheric debris to be about ten years, with an uncertainty of about 25 percent. A maximum value for the stratospheric debris which will fall out with no further testing could be obtained by multiplying the 1956–57 annual fallout by ten (that is, about 110 millicuries per square mile in northeastern United States). This, however, requires the assumption that all 1956–57 fallout was stratospheric. The limited data on the ratio of strontium-89 to strontium-90 (*20*) suggest that the 1956–57 fallout was largely stratospheric in origin. A minimum estimate can be made by accepting Libby's (*19*) estimate of a current stratospheric burden of a fission equivalent of 24 megatons of TNT and by assuming that this will be deposited uniformly over the entire world. This would add 12 millicuries of stratospheric debris per square mile to the surface of the earth. Machta (*21*) has given valid reasons to support the theory of nonuniform deposition of stratospheric debris. His estimates, made on this basis, would lead to a prediction of 60 to 70 millicuries of stratospheric fallout per square mile in the northeastern United States if there should be no further testing.

It is now possible to predict the level of strontium-90 in children's bones in the northeastern United States for 1977 (when most of the stratospheric debris will have fallen out) if it is assumed (i) that no additional debris is introduced into the stratosphere after mid-1957; (ii) that the fallout to mid-1957 is 26 millicuries per square mile, calculated on the basis of Lamont analyses of 18 soil samples taken in the New York City area; and (iii) that the minimum, probable, and maximum estimates for the stratospheric fallout are 12, 65, and 110 millicuries per square mile, respectively. The equilibrium levels of strontium-90 per gram of calcium will be 1.2, 2.9, and 4.3 micromicrocuries of strontium-90 per gram of calcium, respectively.

These data can be calculated for any other geographical location if the level in the soil at mid-1957 is known. At all times the average for North America would be the highest for any land mass,

Table 9. Equilibrium strontium-90 concentration for end-of-1956 diet (discrimination factor 4).

Continent	Concentration ($\mu\mu c$ Sr^{90}/g Ca)
North America	1.1
Europe	0.9
Asia	1.1
South America	0.5
Africa	0.5
Australia	0.5

with the possible exception of the U.S.S.R., and it would in general be higher by a factor of two than that for countries in the Southern Hemisphere (Table 9).

If testing continues at such a rate that the annual deposit of strontium-90 is 10 millicuries per square mile (as it was for the northeastern United States in 1956–57), the equilibrium level on the ground would be 400 millicuries per square mile, since the mean life of strontium-90 is 40 years. The corresponding equilibrium bone level of the population would reach 21 micromicrocuries of strontium-90 per gram of calcium by the year A.D. 2100.

Conclusions

1) For any given station, the strontium-90 content of adult bone is independent of age.

2) The regional differences in the strontium-90 levels in human bone are much smaller than the differences in total fallout. The maximum difference appears to be a factor of two between United States–Europe and the Southern Hemisphere.

3) The average concentration of strontium-90 in the skeleton for most of the world population at the end of 1956 was about 0.20 micromicrocuries of strontium-90 per gram of calcium. The average for North American or European children was about 0.7 micromicrocuries of strontium-90 per gram of calcium, whereas that for adults was lower by a factor of approximately ten.

4) Single bones can be used for estimating the total skeleton concentration of strontium-90 with a precision of about ± 25 percent. The strontium-90 is reproducibly but inhomogeneously distributed in the adult skeleton, but it appears to be more nearly uniform up to the age of about 19.

5) Increase in the strontium-90 content of the diet follows that of the total integrated fallout, but the strontium-90 level in bones lags behind, due to delay in reaching equilibrium.

6) The present distribution of strontium-90 in adult populations is considerably wider than will be the case at equilibrium. It is estimated that, at equilibrium, the urban populations of the world, including those dependent on central food distribution systems (this will represent 80 percent of the people) will be described roughly by a Gaussian distribution with a standard deviation of about ± 40 percent of the mean.

7) The way in which the high values will be distributed is not yet known, but maximum values are expected in areas where the soil has a low calcium content and where local consumption of milk or vegetable foods is low.

8) The predicted levels of strontium-90 concentration for various age groups in present populations, based on known present diet levels and bone growth, agree well with observed values if a discrimination factor between diet and bone of about four is assumed.

9) If there were no further atomic tests after mid-1957, children in the northeastern United States would reach a peak level of 2.9 micromicrocuries of strontium-90 per gram of calcium. The uncertainty in this prediction probably does not exceed a factor of two.

10) If testing continues at a rate such that a certain region receives ten millicuries per square mile per year, (as the northeastern United States did in 1956–57), the equilibrium bone level for the population will be 21 micromicrocuries of strontium-90 per gram of calcium.

Table 10. Present and predicted future levels of strontium-90.

Situation or condition	Level ($\mu\mu c$ Sr^{90}/g Ca)
Industrial MPC.*	1000
Large-population MPC.	100
Average background radiation equivalent [Libby (22)]	50
End of 1956	
World average	0.20
North American children (0 to 4 yr), average	0.67
North American adults, average	0.07
Predicted equilibrium value, North America	1.1
Predicted equilibrium value, Southern Hemisphere	0.5
Future	
Predicted average for children in northeastern United States, 1977 (no further testing—essentially at equilibrium)	
Minimum	1.2
Probable	2.9
Maximum	4.3
Predicted average for population at equilibrium for an area of continuous fallout of 10 mc/mi² yr (A.D. 2100)	21

* Maximum permissible concentration recommended by the International Committee on Radiation Protection.

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5. We wish to express our very great appreciation to the physicians who have cooperated so completely in this program, in many cases at real sacrifice in time and effort. Among those who have assisted us in essential sample procurement are: D. Andersen, C. Brown, J. deBrux, W. Civen, E. Diago, M. Feo, T. Galindo, H. Hamperl, H. Hopps, E. Krieger, W. Leach, J. Legendre, J. Lowry, F. Margarey, H. Menezes, J. Montalvan, T. Potenza, M. Ravelo, G. Roach, D. Rosenberg, A. Stewart, W. Stewart, P. Tamura, G. Teilum, J. Thomson, C. Treip, E. Uehlinger, H. Ungar, G. Volante, S. Warren, and Shu Yeh.
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Frederick George Novy, Pioneer Bacteriologist

On 8 August death ended the long and brilliant career of F. G. Novy (1864–1957). He was one of the early pioneers in bacteriology in this country, having presented the first laboratory instruction in this field in the United States for medical students. This course was given shortly after Dr. Novy and Victor Vaughn returned from a period of study in Koch's laboratory, in 1888.

Novy's research began with chemical studies on cocaine derivatives, which were made as part of his doctoral program in chemistry at the University of Michigan. He then transferred to the Medical School, earned the M.D. degree, and continued on under Vaughn in physiological chemistry. With Vaughn he spent some time studying toxic products of bacteria, "ptomaines." In so doing the two men pioneered in the mass production of pathogenic bacteria. Novy's subsequent studies were more significant and included the differentiation of the relapsing fever spirochetes, study of anaerobes (including the discovery of *Clostridium novyii*), and an investigation of the spirochetes and trypanosomes of birds. A controversy with Shaudinn, who, with Hoffmann, discovered the cause of syphilis, resulted from the latter study. Shaudinn, just before the discovery of the cause of syphilis, suggested a theory, "alternation of generation," to account for the finding of spirochetes or trypanosomes in the blood of birds, depending on when the blood was taken. Novy challenged this observation and correctly so. On the other hand, he quickly accepted the report of Shaudinn and Hoffmann on the etiology of syphilis and congratulated them. Shaudinn accepted the congratulations by letter but remained miffed at Novy's reluctance to accept his "more important" finding of the "alternation of generation" in birds!

In 1909 Novy discovered a virus infecting rats. After some 10 years of work this virus was apparently lost but was then recovered, in 1951, from specimens that had been sealed since 1914–1918. Novy (at this time, age 87) published the results of his earlier studies for the first time, since the virus was again available. The Novy rat virus was the 14th animal virus to be discovered. The course of events in this work illustrates Novy's policy of not rushing into print.

His research also included studies on anaphylotoxin, forerunners of our current concepts of histamine and other substances with marked physiological actions in sensitization reactions. From this work developed another group of observations, on the "primary toxicity of serum," in which he followed the treatment of normal serum with colloidal substances and microorganisms. From current studies one might anticipate that these early observations on primary toxicity of serum will someday have a bearing on the cause of the signs and symptoms of disease and death in infections.

Finally, Novy spent the last years of his active research career on the metabolism of microorganisms, particularly the tubercle bacillus. The techniques developed for the study of the gas exchange and oxygen requirements of microorganisms during growth have since given way to the now widely used Warburg procedures. However, Novy was a pioneer in the field of gas exchange during microbial metabolism.

Many honors came to Dr. Novy in recognition of his professional accomplishments as an investigator and teacher. He received honorary LL.D. degrees from the University of Cincinnati, in 1920, and the University of Michigan, in 1936. He was named Chevalier, Legion d'Honneur (France) in 1924, was awarded the Order of the White Lion (Czechoslovakia) and a Testimonial of the Michigan Legislature, in 1931, and received the award of the 250,000th microscope from Bausch and Lomb Optical Company at the meeting of the American Association for the Advancement of Science in Rochester, New York, in 1936.

Dr. Novy was a charter member of the Society of American Bacteriologists and was the fifth president of the society, in 1904. At the time of his death he was an emeritus member of the National Academy of Sciences.

There remains in the minds of those who were fortunate enough to attend Dr. Novy's classes a vivid memory of a man who, above all, was a clear thinker. He was stern yet kind, strict but tolerant, a demanding taskmaster with a keen sense of humor. His influence will continue to shape the decisions of his students and, in turn, of their students for years to come.

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News of Science

Thermonuclear Reactions

On 24 January the U.S. Atomic Energy Commission and the United Kingdom Atomic Energy Authority released statements and technical reports about recent work in the field of controlled thermonuclear reactions. The most important results obtained so far are (i) the confinement of deuterium plasma at temperatures of 2 to 6 million degrees centigrade for periods ranging from about 1 microsecond to about 5 milliseconds and (ii) the production of up to 100 million neutrons, some of which may result from the fusion of deuterons (deuterium nuclei), during time periods of similar length.

Technical reports. Technical reports on the results achieved in both the United States and Great Britain were published in the 24 January issue of *Nature*. Research scientists in both countries have been working with deuterium gas contained at low pressure (0.4 to 6×10^{-4} millimeters of mercury) in "pinch" tubes of various shapes and sizes. A large electric current (10^5 to 10^6 amperes) is passed through the gas. The current heats the gas and produces a strong magnetic field around the column of hot gas. The magnetic field constricts, or "pinches," the gas discharge to a smaller diameter within the tube, away from the walls, and thus causes further heating of the gas. The magnetic field created by the current also causes the discharge, or "pinch," to wriggle about in the tube; hence, by itself, the field does not prevent the pinch from touching the walls of the tube. Means for minimizing the wriggling of the pinch, or stabilizing it—among them is the application of a magnetic field parallel to the axis of the tube—have been devised.

If the temperature of the pinch is high enough, deuterons collide violently and repeatedly. Most of the collisions result in exchange of energy between one deuteron and another. About half of the remaining collisions produce helium nuclei, energy, and neutrons; the other half produce protons, tritons, energy, and neutrons. The hotter and more confined the pinch, the more frequent the collisions between nuclei, and the more the likelihood of producing a thermonuclear reaction.

In the British experiments, temperatures up to about 5 million degrees centigrade have been produced for periods of 2000 to 5000 microseconds by current pulses of up to 200,000 amperes lasting about the same period; up to 3 million neutrons per current pulse have been observed. In the experiments in the United States, temperatures up to 6 million degrees have been produced for periods of a few microseconds by current pulses of up to 1 million amperes lasting a few microseconds; from 10,000 to 100 million neutrons per current pulse have been observed.

Although neutrons have been detected in the experiments, their source has not been established. In commenting on the source of the neutrons, the British release stated: "There are good reasons to think that they [the neutrons] come from thermonuclear reactions, but they could also come from other reactions such as collisions of deuterons with the walls of the vessel, or from bombardment of stationary ions by deuterons accelerated by internal electric fields produced in some forms of unstable discharges."

The AEC statement reported: "The great majority of the neutrons come from the hot ionized gas. The character and timing of the signals in the neutron detectors, and other physical measurements, encourage the view that the fraction of the neutrons which arise from unwanted voltages due to the instability in the gas or to collisions with the walls and the electrodes, is relatively small."

Strauss' comments. In his commentary on the technical reports, Lewis L. Strauss, chairman of the U.S. Atomic Energy Commission, said: "As I stated on December 18, and as is borne out in the scientific papers released today, both we and the British have succeeded in producing and maintaining quite high temperatures in a plasma of light nuclei, and the containment of such a plasma for brief but nevertheless appreciable lengths of time. But today's reports make it clear that much longer containment must be obtained and much higher temperatures reached.

"Two main conditions are necessary for the attainment of power-producing thermonuclear reactions. First, heavy hydrogen must be brought to a temperature of at least 100 million degrees centigrade. Second, the atomic nuclei in this hot gas must be held together for an appreciable time.

"When the temperature reaches several million degrees centigrade—a result reached in both United States and British laboratories—neutrons are emitted in quantity. However, at such a temperature far below 100 million degrees it is a delicate and difficult matter to distinguish the neutrons produced by fusion from those arising from other processes which are not of particular interest for controlled thermonuclear reactions. Today's reports *suggest* the achievement of neutrons from thermonuclear reactions, but their mode of origin must be positively established. This can be done only by experiments as I have previously noted. Such experiments are continuing in both the United States and the United Kingdom.

"The progress achieved by scientists and engineers associated with the commission's Sherwood program is promising and encouraging and today's reports strengthen confidence which I have had for many years that the difficulties in the way of controlled fusion will eventually be overcome.

"We are making important progress, but the problems are formidable and it will be a matter of years before we will be able to build and operate commercial reactors utilizing the deuterium of the oceans, thus to produce electrical power and provide a source of energy sufficient for man's expanding needs for ages to come.

"It appears that years of intensive work will probably be required to develop a laboratory thermonuclear device which would yield more energy than it consumes. And after that, it will require more years to develop a full-scale power producer. Therefore, the controlled thermonuclear program will not interfere with the current development and construction of reactors to produce electricity from nuclear fission.

"However, the results of our research in the fusion process are sufficiently encouraging and the ultimate rewards are so great as to justify the necessary expenditures of money, time and talent."

British comments. The statement issued by the United Kingdom Atomic Energy Authority commented: "Research at Harwell with the latest apparatus has led British scientists to the conclusion that control of thermonuclear reactions for electricity generation may well be a possibility for the future, though its practical application is still a long way off.

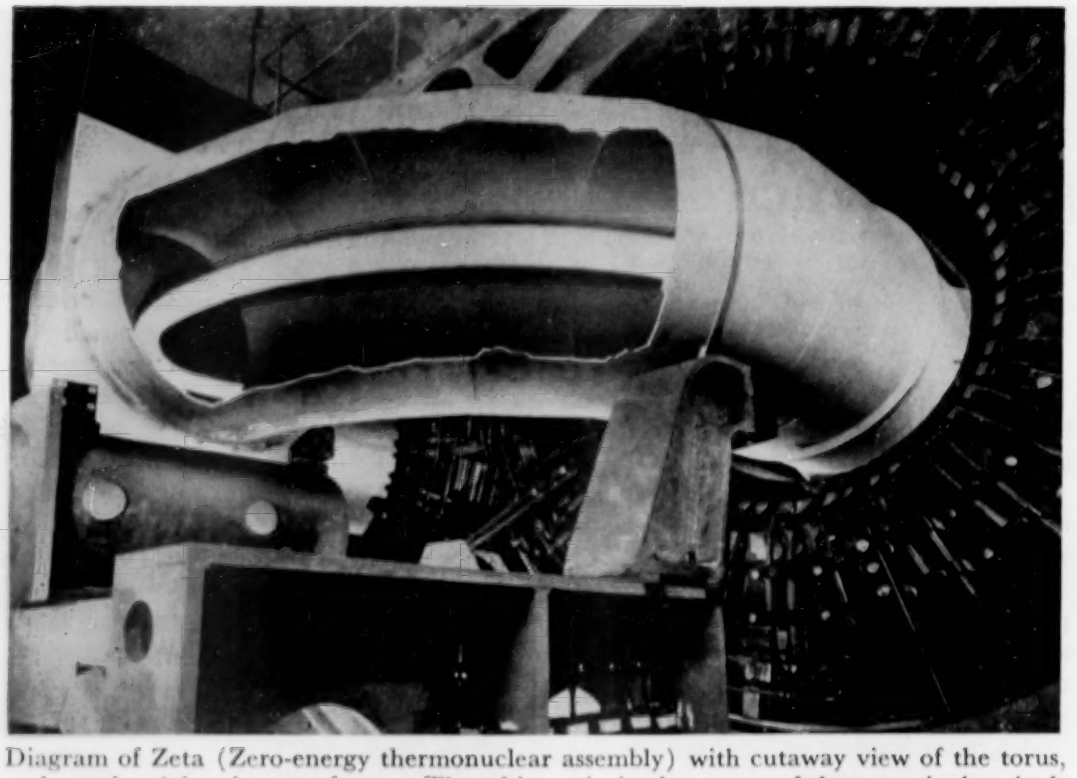

Diagram of Zeta (Zero-energy thermonuclear assembly) with cutaway view of the torus, and, on the right, the transformer. The white strip in the center of the torus is the pinch of hot plasma. [British Information Services]

"The operation of present atomic power reactors is based on the fission (or splitting) of atoms. The possibility now being explored is the harnessing of power from the fusion (or joining) of atoms, which provides the heat for the stars.

"Results obtained from the Harwell apparatus Zeta [Zero-energy thermonuclear assembly] suggest that 'thermonuclear neutrons' have been obtained, but further experiments will be necessary before this can be proved conclusively. Temperatures reached in this apparatus have been as high as 5 million degrees centigrade, higher than the measured surface temperatures of any star.

"Many major problems have still to be solved before its practical application can be seriously considered, and the work must be expected to remain in the research stage for many years yet. If it proves ultimately possible to construct a power station operating on the fusion of deuterium, the oceans of the world will provide a virtually inexhaustible source of fuel . . . .

"In order to obtain a net gain in energy from the reaction it would be necessary to heat deuterium gas to temperatures in the region of 100 million degrees centigrade, and to maintain it at this temperature long enough for the nuclear energy released to exceed the energy needed to heat the fuel and lost by radiation. Lower temperatures would suffice for a deuterium-tritium mixture. The high temperatures achieved in Zeta, and the relatively long duration for which the hot gas has been isolated from the tube walls, are the most important experimental results obtained so far. Whilst a much longer time (perhaps several seconds) is required for a useful power output, there appears to be no fundamental reason why these longer times, together with much higher temperatures, cannot be achieved.

"There are, however, many major problems still to be solved before its practical application can be seriously considered, and the work must be expected to remain in the research stage for many years yet."

Zero-energy thermonuclear assembly (Zeta). The British results have been obtained with two toroidal pinch tubes, Zeta and Sceptre III. Zeta was first operated on 12 August 1957 at the Atomic Energy Research Establishment, Harwell. Work with Zeta was described in an article in *Nature* by P. C. Thonemann, R. Carruthers, D. W. Fry, R. S. Pease, G. N. Harding, S. A. Ramsden, E. P. Butt, E. McWhirter, D. J. Lees, A. Dellis, S. Ward, and A. Gibson.

In Zeta the discharge chamber is a torus of aluminum of 1 meter bore and 3 meters mean diameter. The pressure of deuterium is usually about 10^{-4} millimeters of mercury. The plasma in the torus forms the secondary of a large pulse transformer. A pulse of electric current is passed into the primary of the pulse transformer by discharge of a bank of capacitors which stores a maximum of 500,000 joules. This pulse induces a large current in the gas, which is, in effect, the short-circuited secondary of the transformer. Currents up to 187,000 amperes, lasting for 3 to 4 milliseconds, are induced in the gas. The pulse is repeated every 10 seconds. Instabilities in the pinch are suppressed by a magnetic field that is imposed parallel to the pinch and by electric fields produced in the metal walls of the torus by eddy currents. Emission of 1.34 million neutrons per current pulse is reported. The calculated temperature is 4.65 million degrees Kelvin.

The methods of measuring the temperature were described as follows in the British AEA statement: "The temperature of gas discharges may be determined from measurements on the light emitted by the gas atoms, but measurements of this kind in these experiments present problems because, at the temperature of the discharge, the hot deuterium atoms are completely stripped of their electrons, and therefore do not emit a line spectrum. One method of solving this problem is to mix with the deuterium a small quantity of some heavier gas, such as oxygen or nitrogen, the atoms of which are not stripped of all their electrons under these conditions, and to study the spectral lines emitted by this impurity; the random motion of the high-energy impurity atoms which make many collisions with the deuterium atoms and so reach the same energy causes the spectral lines to broaden, owing to the Doppler effect, and the amount of broadening is a measure of the ion energy. Many measurements by this method have indicated temperatures in the region of 2 to 5 million degrees centigrade. Whilst temperatures in this range are required to explain the observed rate of neutron production on the basis of a thermonuclear process, electric fields in the gas arising from instabilities can also accelerate deuterium ions and lead to nuclear reactions. Such a process was described by Academician Kurchatov in his lecture at Harwell in 1956. Therefore it is not altogether certain that the observed neutrons come from a thermonuclear reaction. Experiments are continuing to study the details of the neutron-producing processes."

Sceptre III. Sceptre III is an aluminum torus that has been built at the research laboratories of Associated Electrical Industries Limited, Aldermaston, Berkshire, near Harwell. Work with this apparatus was described in *Nature* by N. L. Allen, T. E. Allibone, D. R. Chick, R. E. Hemmings, T. P. Hughes, S. Kaufman, B. S. Liley, J. Mack, H. T. Miles, R. M. Payne, J. Read, A. A. Ware, J. Wesson, and R. V. Williams. These workers have received advice from Sir George Thomson, who began experimental work in the field at Imperial College in 1947.

The torus of Sceptre III has an internal bore of 30 centimeters and a mean diameter of 115 centimeters. Temperatures of about 4 million degrees Kelvin were attained for a period of a few microseconds. Neutron yields ranged from 1200 to 100,000 per pulse. According to an article by R. K. Plumb in the

New York Times for 25 January, the cost of this apparatus was $28,000, much less than the costs of the apparatus used by the respective government agencies. Plumb also noted that the workers at Associated Electrical Industries are much more optimistic about developing higher temperatures within a reasonably short time than the AEC and the AEA: "... temperatures of ten to twelve million degrees are hoped for in a few months."

Columbus. Five papers by scientists from the United States were published in the 24 January issue of *Nature*. L. C. Bankhardt, R. H. Lovberg, and J. A. Phillips of Los Alamos Scientific Laboratory described measurements made in mid-1956 of the distribution of currents in a linear, pinched discharge in deuterium. The measurements provide a means for determining the effective temperature of the hot gas.

The production of neutrons in a straight pinch apparatus was described by D. C. Hagerman and J. W. Mather, also of Los Alamos. This apparatus, Columbus II, is 30 centimeters long and 10 centimeters in diameter; it began to yield results last summer. Under various conditions the tube can be made to yield between 10 million and 100 million neutrons per pulse, in a time of about 1 microsecond or less.

Tests were made to determine whether most of the neutrons are produced by thermonuclear reactions or whether they are emitted at the electrodes or walls, or from instabilities in the gas. It was found that the neutrons are emitted from the gas and that they come practically uniformly from all parts of the tube.

The third paper, by L. C. Burkhardt and R. H. Lovberg, dealt with another straight pinch tube, Columbus S-4. This tube is a porcelain cylinder 5 inches in diameter and 24 inches long. The paper showed that there can be circulating currents in the tube at certain times during the pinch process. Particle energies of 300 electron volts (or temperatures of about 3 million degrees) were attained, in spite of the fact that the tube was operated at voltages below 20 kilovolts. When the tube was started with pressures of 40 microns of mercury, the pressure became 12 atmospheres at the time when the diameter of the current column was smallest, about 6 microseconds after the current started. According to the AEC release, "Perhaps the most significant observation with S-4 is that the field produced by the pinch current is highly reproducible over several half-cycles of the applied voltage."

Perhapsatron. The fourth paper from Los Alamos was written by J. Honsaker, H. Karr, J. Osher, J. Phillips, and J. L. Tuck. It described the production of neutrons from a stabilized pinch in a small doughnut-shaped tube, the Perhapsatron S-3. This tube came into operation in December 1957; it yielded as many as 1 million neutrons per discharge. The main burst of neutrons occurs in a time of about 2 microseconds. Smaller bursts continue to occur for several additional microseconds. The results are felt to be consistent with an effective temperature of about 6 million degrees. There is good evidence that the pinch is well centered while the applied current is high; the amplitude of the undulations of the pinch is about 2 millimeters, which suggests that the discharge is well stabilized.

Two other papers by scientists from the United States were released on 24 January. One, the fifth of the group published in *Nature,* was an analysis of the results obtained by the British workers with Zeta, by Lyman Spitzer, Jr., of Princeton University. The other described the production of neutrons in linear deuterium pinches. It was written by D. A. Anderson, W. R. Baker, S. A. Colgate, H. P. Furth, J. Ise, Jr., R. V. Pyle, and R. E. Wright, of the University of California Radiation Laboratories, Livermore and Berkeley, and was published in the 1 February issue of the *Physical Review.*

Cooperation in research. The British release stated: "Full collaboration in the controlled thermonuclear reactions field was established with the U.S. Atomic Energy Commission in October 1956."

Lewis L. Strauss, chairman of the U.S. Atomic Energy Commission, stated: "After the U.S.-U.K. decision to declassify results of work on controlled thermonuclear reactions (except for certain areas) and following necessary concurrence of the two countries on a revision of the Joint Classification Guide to accomplish this, conferences began with a view to releasing the newly-declassified information as early as possible in 1958. It was agreed that January 24, 1958, was the most convenient date.

"Assertions that U.S. pressure was used to persuade the U.K. authorities to suppress publication of the results of their research are contrary to the fact and have been refuted by Sir Edwin Plowden, chairman of the United Kingdom Atomic Energy Authority, and by me.

"Furthermore, certain comparative observations which have been published in recent weeks about British and U.S. progress in this field will be seen from today's British and U.S. papers to have been not only misleading but lacking in any foundation of fact.

"Today's announcements make it clear that fruitful and promising results have been achieved in the laboratories of both countries but we should not expect early harnessing of fusion for the production of power. In the field of fusion, we are not yet at a point comparable to December 2, 1942, when the first self-sustaining fission reaction was obtained.

"Our research efforts and those of the United Kingdom are at a point where it occurs, periodically, that first one laboratory and then another will make a useful and illuminating advance. This has happened in the past, and no doubt will occur in the future, as our two countries pursue their studies . . . .

"We congratulate the United Kingdom Atomic Energy Authority and its scientists and engineers for the notable advances which they have made. We are happy with the cooperation which we have established with our British friends in this field of science, and we confidently expect it to expand the frontiers of knowledge."

Petition Urging Agreement To Stop Nuclear Tests

Linus Pauling announced on 20 January that 9235 scientists in 44 countries have signed a petition to stop the testing of nuclear bombs by international agreement and that he had presented the petition to the United Nations. The petition bears the names of 36 Nobel laureates, 101 members of the National Academy of Sciences of the United States, 35 Fellows of the Royal Society of London, and 216 members and correspondents of the Academy of Sciences of the U.S.S.R.

A total of 2705 American scientists signed the petition. There were 216 Russian names, 304 from the United Kingdom, 65 from France, and 1141 from Japan.

The petition was prepared by Pauling as an individual scientist and was signed by other scientists as individuals. No organization was involved in the formulation of the petition or in the collection of signatures.

The petition resulted from an address on "Science in the Modern World" given last May at Washington University, St. Louis, Missouri. In the address Pauling discussed the damage that is being done by the testing of nuclear bombs and expressed his conviction that a stop to the testing through international agreement would be an effective first step toward averting a cataclysmic war, and that international problems should be solved not by war, but by the application of man's power to reason, through arbitration, negotiation, international agreements, and international law.

Within 2 weeks the signature of 2000 American scientists had been obtained, and on 4 June 1957 the statement was submitted to President Eisenhower [*Science* **125**, 1190 (14 June 1957)].

In July Pauling received a statement of adherence to the petition signed by all of the professors of science in the Free University of Brussels, as well as similar statements from scientists of other countries. He then wrote to a few scientists in each country, asking that they obtain signatures. In some countries no effort was made to obtain signatures except from a few leading scientists.

Pauling has stated that he does not believe that the problem of bomb tests and disarmament is one that should be settled by scientists; it is instead one of importance to every person in the world. Scientists, however, have some measure of understanding of the complex factors involved, such as the magnitude of the damage done by radioactive fallout, and he believes that scientists have an obligation to express their opinions in order to help their fellow citizens. He also has said that he advocates an agreement to stop bomb tests and that such an agreement would benefit all nations and all people equally and not one nation or group of nations preferentially.

Sun Spot Theory

A new theory about sun spots has been advanced by Donald H. Menzel, director of the Harvard College Observatory, in the annual report of the Smithsonian Institution. Heretofore, the spots were assumed to indicate the existence of solar storms, or the vertices of cyclones. However, in the report, Menzel says the small, dark regions are "islands of intense calm floating in the otherwise turbulent sea of the sun's atmosphere."

The report on the new theory states: "We are now in a position to understand the darkness of the sunspot relative to the surrounding photosphere. In a region where magnetism has not inhibited convection, the outer layers are hotter than they would be otherwise. They are, consequently, more luminous than the spots, where convection does not occur. In the region immediately surrounding the spots, the convective layer must rise higher."

Tariff-Free Instruments

A bill to permit certain educational organizations to import free of duty scientific and laboratory apparatus for educational or scientific purposes was introduced last August in the House of Representatives by Congressman Anton N. Sadlak of Connecticut. It was referred to the Committee on Ways and Means. The bill, H.R. 9349, proposes that the Tariff Act of 1930 be amended to permit the free import of "scientific or laboratory instruments, apparatus, utensils, or appliances (including surveying and mathematical instruments), or parts thereof, imported by a tax-exempt educational organization for its own use in scientific research or in the instruction of students, and not for sale (including sale to students) or for any commercial use."

Standard Inch

Standardization of the inch among friendly nations in an age of increasing weapon precision was urged recently by A. V. Astin, director of the National Bureau of Standards. He asserted that the fractional differences between the inches used in the United States, the United Kingdom, and Canada have created critical problems in technological cooperation.

Astin said there were 129 calibration centers throughout the Soviet Union for passing on the accuracy of instruments in weapons and missiles plants and in military installations. The United States probably has superior tools of standardization, but the Russians appear to have superior means of distribution in that field.

Astin proposed that the appropriate agencies of the United States, the United Kingdom, and Canada negotiate an international yard of 0.9144 of an exact international meter. This would yield an international inch equal to 2.54 centimeters. This is exactly the Canadian standard and about midway between the United States and British standards.

Tenth Anniversary of the American Heart Association

Marking its first decade as a national voluntary health agency, the American Heart Association has announced that, by the end of the current fiscal year, the association and its affiliates and chapters will have channeled a total of $29 million into research studies. Research allocations for the current fiscal year total nearly $7 million, the highest annual amount since the awards were first made in 1948. More than 60 percent of the awards are for basic research.

In noting the 10-year gains in cardiovascular research, the anniversary issue of the association's *Heart Research Newsletter* states:

"Outstanding have been the dramatic achievements of surgeons in repairing previously hopeless heart defects. New drugs have appeared to help those with high blood pressure. Improved drugs and diet therapy have helped heart failure patients. Rheumatic fever seems to be yielding to prevention. Anti-clotting drugs have been shown to reduce the death rate after the first heart attack and long-term anticoagulant therapy has been extensively studied.

"The application of electronics and the use of radioactive tracers have given investigators important new tools and provided physicians with improved methods of diagnosis. The catheter, a long thin tube pushed up through the veins into the heart chambers, has become widely used as a method for diagnosing heart and circulatory malfunctions. The value of regular exercise, the need to keep down weight, and sensible diet precautions have been affirmed."

News Briefs

An information exchange program linking Fordham University and the Catholic University of Lublin, Poland, has been announced. Heading the program at Fordham is the Rev. Walter C. Jaskievicz, director of the Institute of Russian Studies. He will direct the exchange of photographs, books, special editions of student newspapers, art exhibits, tape recordings, and newsletters. The program was arranged with the cooperation of the Department of State.

* * *

The first issue of *Ergonomics: Human Factors in Work, Machine Control and Equipment Design,* has been announced by Academic Press Inc., distributors of the journal in the United States and Canada. The term *Ergonomics* was coined to denote an approach to the problems of human work and control operations which came into prominence during the second world war in relation to equipment for the armed services. The general editor of the journal, the official publication of the Ergonomics Research Society, is A. T. Welford, Psychological Laboratory, Cambridge University, Cambridge, England. Subscription orders originating in the United States and Canada should be addressed to Academic Press Inc., 111 Fifth Ave., New York 3, N.Y.

* * *

The University of Michigan will build an 85-foot steerable radio telescope next June at Peach Mountain, 16 miles from Ann Arbor.

* * *

The National Bureau of Standards has developed a simple, fast-acting, precision instrument to measure the speed of sound in nondispersive liquids—liquids in which the speed of sound is essentially independent of frequency. M. Greenspan and C. E. Tschiegg of the

bureau's sound laboratory designed and constructed this instrument under the sponsorship of the Office of Naval Research. It has been used to measure the speed of sound in distilled water from 0° to 100°C with an accuracy of 1 part in 30,000.

* * *

The National Academy of Sciences–National Research Council has released a report of an inquiry into the underground disposal of radioactive waste from atomic energy installations. Conducted by the Committee on Waste Disposal of the Academy–Research Council's Division of Earth Sciences, under contract with the U.S. Atomic Energy Commission, the 3-year study was based on a conference held 10–12 September 1955 at Princeton University. The report and edited proceedings of the Princeton conference are contained in *The Disposal of Radioactive Waste on Land,* which may be obtained for $1 from the Publications Office, National Academy of Sciences–National Research Council, 2101 Constitution Avenue, NW, Washington 25, D.C.

* * *

The American Veterinary Medical Association has announced the establishment of the American Board of Laboratory Animal Medicine. A brochure that describes the board is ready for distribution. Applicants applying for membership *before 18 February* may be admitted to the board without examination; after that date, all applicants must take the board examination. For information, write to: Dr. Robert J. Flynn, Argonne National Laboratory, Box 299, Lemont, Ill.

Scientists in the News

Among the five first recipients of the President's award for "exceptionally meritorious civilian service" to the Government were STERLING B. HENDRICKS, chief chemist in the Department of Agriculture's pioneering research laboratory for mineral nutrition of plants, and WILLIAM B. McLEAN, technical director of the Naval Ordnance Test Station at China Lake, Calif. Hendricks was cited for "extraordinary and versatile achievement through basic research in the Department of Agriculture," and McLean was honored for conception and development of the Navy's "sidewinder" guided-missile weapons system. The two men received gold medals at a ceremony that took place in the White House on 27 January.

HOWARD W. POTTER has retired as professor and chairman of the department of psychiatry at the State University of New York's Downstate Medical Center in Brooklyn. A member of the faculty of the College of Medicine of the Downstate Medical Center and its predecessor, the Long Island College of Medicine, for 20 years, Potter has been chairman of the department of psychiatry since 1947. In addition, he served as acting dean of the College of Medicine from September 1954 to June 1955, and as dean from June 1955 to September 1957. He has also been director of psychiatry at the Kings County Hospital Center since 1947.

Potter began his career as a psychiatrist at the Bloomingdale Hospital, the psychiatric division of New York Hospital, in 1916. Later he organized and directed a research department at Letchworth Village, a state institution for mental defectives at Thiells, N.Y. In 1929 he was appointed assistant director and chief of staff of the newly erected psychiatric institute and hospital at the Columbia Presbyterian Medical Center, where he also held the title of clinical professor of psychiatry.

Potter has accepted an appointment as visiting professor of psychiatry at the University of the Philippines College of Medicine, where he will act as a consultant to the dean in developing a program of psychiatric education. He expects to spend several months each year in the Philippines for the next few years. In addition, he will organize and direct an intensive course in mental deficiency at Letchworth Village for doctors specializing in psychiatry.

Potter received his M.D. degree from the College of Physicians and Surgeons of Columbia University in 1913. During World War II he was medical supervisor of the Port of New York for the Merchant Marine War Shipping Administration. In 1943, as director of psychiatry of the Long Island College Hospital, he founded the William Alanson White Psychiatric Clinic on Amity Street, Brooklyn.

ARNE G. H. RHODIN, Swedish electron microscopist who is at present an assistant professor in the department of anatomy at the Karolinska Institute in Sweden, has accepted an appointment as an associate professor in the department of anatomy at New York University College of Medicine.

MRS. LAURENCE PELLIER has been appointed applications chemist by the Norelco Instruments Division, Philips Electronics, Inc., Mount Vernon, N.Y. She will devote her attention to technical problems involving electron microscope techniques. Mrs. Pellier was formerly research metallurgist for the Sigmund Cohn Corporation, Mount Vernon, and was concerned with the design of alloys for electrical and electronic instruments.

GEORGE W. BEADLE, professor of biology and chairman of the Biology Division of California Institute of Technology, has been appointed Eastman visiting professor at the University of Oxford, England, for the academic year 1958–59. The Eastman professorship was founded in 1929 by George Eastman to bring senior American scholars to Oxford University for a year. The fund supporting the professorship is administered by the Association of American Rhodes Scholars.

ELLIS A. JOHNSON, director of the Operations Research Office, Johns Hopkins University, has received the Army's Distinguished Civilian Service Medal "for his distinguished ability and performance."

Pergamon Press has announced that WILLIAM DOERING has accepted the regional editorship for the American continent of *Tetrahedron,* following the death of Morris S. Kharasch. Manuscripts for publication should be addressed to Prof. William Doering, Sterling Chemistry Laboratory, Yale University, 225 Prospect St., New Haven, Conn.

L. J. AUDUS, professor of botany and head of the botany department at Bedford College, University of London (England), will be visiting professor in the department of botany, University of California, Berkeley, for the spring semester. He will present a lecture and laboratory course on the physiology of plant growth and development.

WESTON S. EVANS, head of the civil engineering department at the University of Maine, has been named dean of the university's College of Technology. He has been serving as acting dean of the college since the resignation of ASHLEY S. CAMPBELL last summer. In addition to serving as dean, Evans will also be director of the Technology Experiment Station.

In tribute to LOUIS W. SAUER, pediatrician of Evanston, Ill., who developed the whooping cough vaccine, the North Suburban Branch of the Chicago Medical Society prepared a panel of the citations awarded the physician for his contributions to medicine. The panel, which bears three citations and Sauer's picture, was presented to him at a recent meeting of the branch.

CARL C. LINDEGREN, director of Southern Illinois University's Biological Research Laboratory, will receive the annual Pasteur Award of the Society of Illinois Bacteriologists at a dinner on 28 February in the Morrison Hotel, Chi-

cago. He is a geneticist and specialist in yeasts and the author of *The Yeast Cell: Its Genetics and Cytology*. Lindegren was the first to discover that yeast cells have sex and that they can be cross-bred to develop new types of yeast strains. He and his coworkers also found that induced changes in a yeast cell can be inherited by the cell's offspring.

PETER P. HOPF, product development manager for A. Boake, Roberts & Co. Ltd., London, England, will be in the United States during the period 9–30 April to exchange with chemical manufacturers and users technical and commercial information of mutual interest.

LEO M. HURVICH, formerly with the color technology division of the Eastman Kodak Company, Rochester, N.Y., has joined the department of psychology of New York University as professor of psychology.

RILEY SCHAEFFER, associate professor of chemistry at Iowa State College, has been appointed associate professor of chemistry at Indiana University, effective in September.

CHARLES R. MINGINS, head of the department of physics and mathematics at Lowell Technological Institute, has been appointed chairman of the institute's Division of Engineering. He replaces HARRY C. BROWN, who has retired.

JOHN F. BAXTER, professor of chemistry at the University of Florida, has been relieved of his teaching duties to devote full time to conducting a high-school chemistry course before motion picture cameras. The course will consist of 160 half-hour films, designed to aid high-school science departments.

R. P. BELL of Balliol College, Oxford University, England, will give the Baker lectures in chemistry at Cornell University during the 1958 spring term, on the topic, "The Proton in Chemistry." MELVIN CALVIN of the University of California will deliver the Baker lectures in the fall of 1958. C. A. COULSON, of Oxford University, will be Baker lecturer for the spring term, 1959.

TIMOTHY R. TALBOT, JR., assistant professor at the University of Pennsylvania Medical School, has been appointed director of the Institute for Cancer Research, Philadelphia.

Five top posts have been filled in the newly reorganized U.S. Fish and Wildlife Service of the Department of the Interior. In the Bureau of Commercial Fisheries, ALBERT L. TESTER, formerly director of the Pacific Oceanic Fisheries Investigations at Honolulu, T.H., is chief of the new Division of Biological Research, which will handle investigations pertaining to the anadromous fisheries, marine and inland fisheries, and the shellfish fisheries. Previously these activities were conducted by the Branch of Fishery Biology.

HAROLD E. CROWTHER, formerly coordinator of the Saltonstall-Kennedy Program work, and who was in charge of setting up the Fisheries Loan Fund unit, is chief of the Division of Industrial Research and Services. This division has taken over the functions of the former Branch of Commercial Fisheries in the field of economics, exploratory fishing and gear research, dissemination of daily fishery market news, statistical canvasses and studies, market development activities, and technological research.

RALPH C. BAKER, formerly assistant chief of the Branch of Alaska Fisheries, is head of the Division of Resource Management. This organizational unit is responsible for the Alaska fishery and fur-seal programs, the Columbia River fishery development program, and the enforcement of laws and regulations relating to the management of commercial fisheries and marine mammals under international fishery conventions.

In the Bureau of Sport Fisheries and Wildlife, ROBERT M. RUTHERFORD, formerly chief of the Branch of Federal Aid, is the new chief of the Division of Technical Services. This division is responsible for the administration of the Pittman-Robertson wildlife and the Dingell-Johnson sport-fish restoration programs, river basin activities, and engineering and realty services.

The Division of Sport Fisheries is headed by JOHN S. GOTTSCHALK, formerly assistant chief of the Federal Aid Branch of the Service. This division has charge of the operation of all the service hatcheries and supervises the programs involving the management of the sport fish resources and the conduct of fundamental research on these species.

MAX REISS has been appointed director of research at Willowbrook State School, Staten Island, N.Y., where he will head a new unit to investigate mental retardation, combining the techniques of clinical psychiatry, biochemistry, and endocrinology. Since 1950 Reiss has served in England as consultant in mental health of the South Western Regional Hospital Board under the Ministry of Health. In 1954 he was appointed honorary consultant to St. Ebba's Hospital, Epsom, and to the Royal Victoria Hospital at Netley, Hants, the British War Office's main hospital for psychiatric casualties.

JOSEPH B. WOLFFE, cardiologist and president of the American College of Sports Medicine, will represent the United States at the twelfth Congress of the International Federation of Sports Medicine to be held in Moscow on 29 May. Wolffe, founder and director of the Valley Forge Heart Hospital and Medical Center in Fairview Village, Pa., and of the Wolffe Clinic and Hospital in Philadelphia, has studied the effects of athletics and other forms of vigorous activity on the heart and blood vessels.

Two Harvard University professors have been granted leaves of absence to serve as consultants in medical education to the King George Medical College of Lucknow University, Lucknow, India. They are EDWARD D. CHURCHILL, Homans professor of surgery at Harvard and chief of surgical services at Massachusetts General Hospital, and HERMANN BLUMGART, professor of medicine at Harvard and chief of medical services at the Beth Israel Hospital.

THOMAS D. FONTAINE has been named program director for fellowships in the Division of Scientific Personnel and Education at the National Science Foundation. Fontaine, who has served for the past 2½ years as administrative assistant to Sen. John C. Stennis of Mississippi, was previously a research chemist with the U.S. Department of Agriculture.

EDWIN A. SPEAKMAN, former vice president and general manager of the Fairchild Engine and Airplane Corporation's Guided Missile Division, has been named to the newly created post of manager of planning for defense electronic products, Radio Corporation of America.

CARL H. KEYSSER has been named research associate in pharmacology at the Squibb Institute for Medical Research, New Brunswick, N.J. Keysser, born and educated in Berlin, Germany, spent several years after World War II as head of the clinical chemistry department at the Friederikenstift General Hospital in Hanover, and as head of the department of medical chemistry at the Südmedica Pharmaceutical Company in Munich. Then in 1956 he became assistant pathologist at Misericordia General Hospital in Winnipeg, Canada, and for the past year he has been an assistant in pathology at the West Jersey Hospital in Camden, N.J.

Erratum: One component (*i*-inositol at a concentration of 0.002 g/lit) of the nutrient medium was omitted from Table 1 of the article "Molecular Growth Requirements of Single Mammalian Cells," by G. Sato, H. W. Fisher, and T. T. Puck [*Science* **126**, 961–964 (8 Nov. 1957)].

Reports

Displacement of Serotonin from Tissues by a Specific Antimetabolite

The mode of action of an antimetabolite seems to be to occupy the specific receptors normally used by the metabolite. The result is a displacement of that metabolite and creation of a deficiency of it (*1*). Actual measurement of this displacement, however, has been made in relatively few cases (such as, for example, the displacement of acetylcholine by antiacetylcholines and of thiamine by pyrithiamine), and for this reason it may be desirable to study the situation with other metabolite-antimetabolite pairs in order to establish the generality of the phenomenon. Because we had available a potent and highly specific antimetabolite of serotonin, we thought it desirable to determine whether this compound would indeed displace serotonin from its sites in animal tissues. This antimetabolite was 1-benzyl-2-methyl-5-methoxytryptamine (BAS), the benzyl analog of serotonin, which has recently been shown to be quite active (*2*), and very specific (*3*) as an antagonist of serotonin in living animals.

One would expect to find that BAS would displace serotonin from tissues rich in this hormone. Actual trial with platelets from rabbit blood showed that this occurred. The serotonin content of the platelets isolated from individual rabbits was measured, and the animals were then given BAS (15 mg/kg, intraperitoneally, daily for 3 days). Platelets were again isolated 1 hour after the last dose of BAS and analyzed for serotonin. The data given in Table 1 show that the BAS lowered the serotonin content.

In order to make sure that the difference observed was not the result of capricious variation from day to day in the serotonin content or in the platelet count and that similar differences might not occur in untreated animals, each rabbit was examined at least twice before the administration of the BAS and at several intervals after this administration. These experiments showed that the values for serotonin content per platelet and for serotonin content per milligram of platelet protein, as well as for serotonin per milliliter of blood (calculated from the analysis of the platelets isolated from the blood), were substantially the same from day to day. After administration of BAS, however, the serotonin content fell to about half the normal values. It was evident that this fall did not occur immediately after injection of the BAS, because blood samples taken 1 hour after the first injection showed no decline in serotonin content of the platelets (in fact, there was a slight rise). It is already known that BAS is characterized by the slow onset of its antiserotonin action, and the present findings illustrate another facet of this property.

The analyses for serotonin were performed by the colorimetric method of Udenfriend *et al.* (*4*) on platelets isolated by the method of Dillard *et al.* (*5*). Platelets were counted in the whole bloods and in the final washed suspensions. About 50 percent of these cells were retrieved. The analytical values given in the last column of Table 1 reflect corrections made for this loss that occurred during isolation.

The validity of the chemical measurements, and of this last point relative to actual content in the whole blood, was checked as follows. Blood from the same rabbits was analyzed by the method described above and also by the pharmacological method for determining serotonin content (*6*), in which the rat uterus is utilized. Whole blood was cytolyzed with distilled water and analyzed directly by means of this pharmacological technique. In order to make sure that the pharmacological effect was due only to serotonin, the dilutions of blood were assayed on a uterus before and after the muscle had been treated with BAS. It is known that BAS specifically blocks the response of a tissue to serotonin. These experiments showed that at least 90 percent of the pharmacological effect was due to serotonin. The quantitative assays showed that the serotonin content of the whole blood of each rabbit was essentially the same as that determined by the colorimetric analysis of the platelets contained therein. Thus, rabbit E gave a value of 10 μg of serotonin per milliliter by the assay of whole blood and 10 μg per milliliter as determined by colorimetric analysis of the isolated platelets with correction made for percentage yield of platelets. Finally, the entire experiment on the lowering of serotonin content by administration of BAS was repeated on three rabbits, but the measurements were made pharmacologically as indicated. These showed that the BAS reduced the average serotonin content of blood from 10.5 to 4.8 μg/ml.

Measurements were also made of the effect of BAS administration on the serotonin content of stomach and small intestines of mice. Both colorimetric and pharmacological methods showed that a slight reduction occurred but that the reduction was not as marked as in the case of rabbit blood. Measurements on the urine of mice treated with BAS showed that excretion of 5-hydroxyindoleacetic acid was not increased but that the urinary excretion of serotonin was markedly increased. Apparently, the BAS inhibited the action of amineoxidase, and consequently the displaced serotonin was excreted largely unchanged.

The finding that there is a displacement of serotonin from tissues by a specific antimetabolite of serotonin may have some bearing on the ideas currently being discussed about the mode of action of reserpine. Pletscher *et al.* (*7*) showed that reserpine displaced serotonin from tissues of animals, and from this finding many hypotheses about the mode of action of the drug have been put forward. We suggest that this displacement of serotonin may be an expression of the antiserotonin activity of reserpine. It had been shown before the structure of reserpine was known that

Table 1. Serotonin content of rabbit blood platelets before and after treatment of animal with BAS. Values shown are the average of determinations on four rabbits.

Yield of washed platelets (%)	Serotonin content (μg per 10^9 platelets)	Serotonin content (μg/mg of platelet protein)	Serotonin content (μg/ml of blood)
No treatment			
47	2.7	16.1	9.4
1 hr after administration of BAS			
44	3.1	20.6	8.2
After 2 days' administration of BAS			
52	1.0	10.0	5.0

All technical papers and comments on them are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table or one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

yohimbine was a potent antimetabolite of serotonin (*8*), and when it was learned that reserpine is a derivative of yohimbine, it seemed likely that it would have a similar type of action. It may be that some of the pharmacological effects of reserpine arise from an antiserotonin property. The ability of reserpine to displace serotonin from tissues is clearly a type of action possessed by bona fide antimetabolites of serotonin, such as BAS (*9*).

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28 October 1957

Unstable Nucleic Acids of Rickettsia mooseri

Cells of *Rickettsia mooseri*, when purified and suspended in isotonic media, rapidly lose certain of their biological properties at 0°C (*1*). This inactivation can be attributed, in part, to a progressive loss of diphosphopyridine nucleotide (DPN) from the rickettsiae into the suspending medium. Incubation of partially inactivated rickettsiae with excess DPN results in a restoration of their various biological functions (*1, 2*).

Attempts were made, therefore, to determine whether rickettsiae lose other important cofactors besides DPN. Purified suspensions of *R. mooseri* which had been freshly prepared by methods that have been described previously (*3*) were extracted with 5 percent cold perchloric acid in order to obtain the "acid-soluble fraction." In the case of many bacteria, this fraction contains the cofactors and metabolites of low molecular weight (*4*). The rickettsial extracts possessed an ultraviolet absorption spectrum typical of purine and pyrimidine compounds, with a maximum at 260 mμ. Chromatographic analysis performed on lyophilized extracts revealed the presence of four clearly defined ultraviolet absorbing spots, two of which were adenosinediphosphate and DPN. The other two compounds have not yet been identified.

Aliquots of the same purified rickettsial suspension were incubated at 36°C, and samples were taken at intervals over a 3-hour period. In these samples the rickettsiae were sedimented at 22,000*g* for 15 minutes (Sorvall centrifuge model SS-1), and the optical densities (at 260 mμ) of the acidified supernatants were determined. It became apparent that, during 3 hours, more 260-mμ-absorbing materials were liberated than could be accounted for by the total quantity of material extractable at the onset of the experiment. The nucleic acids of the rickettsiae were thought to be a likely source of the excess material liberated.

Rickettsia mooseri was, therefore, analyzed for both types of nucleic acids. Freshly prepared suspensions of the organism were fractionated after the method of Schmidt and Thannhauser (*5*), and analyses of the fractions for phosphorus (*6*), pentose (*7*), and deoxyribonucleic acid (DNA) (*8*) revealed the presence of ribonucleic acid (RNA) (22.6 μg of RNA-phosphorus per milligram of nitrogen) and DNA (6.3 μg of DNA-phosphorus per milligram of nitrogen) in a ratio of 3.5:1, which resembles that reported for many bacteria (*9*).

After these analytical findings had become available, balance studies were performed on the liberation of 260-mμ-absorbing materials from the cells of *R. mooseri*. Six experiments have been performed, and one typical protocol is presented in Table 1. Immediately after preparation, purified suspensions of rickettsiae were diluted with the reagents previously employed in manometric studies on glutamate oxidation (*3*). These mixtures were incubated at 36°C

Table 1. Changes in the distribution of ultraviolet-absorbing materials in rickettsial fractions upon incubation.

Time (min)	Optical density (260 mμ)			
	Suspending medium	Rickettsiae extracted with 5% PCA		Total
		Cold	Hot	
Incubated at 36°C				
0	0.22	0.94	7.32	8.48
60	0.74	0.94	6.79	8.47
120	0.96	1.00	6.46	8.42
180	1.15	1.00	6.28	8.43
Incubated at 4°C				
0	0.22	0.94	7.32	8.48
60	0.24	1.10	7.13	8.47
120	0.27	1.19	6.98	8.44
1200	0.39	1.35	6.72	8.46

Table 2. Reactivation of the toxicity of *Rickettsia mooseri* after inactivation at 4°C and at 36°C.

Treatment		Toxicity (LD_{50})	(%) Reactivation
Inactivation	Reactivation		
None	None	1:780	
18 hr, 4°C	None	< 1:20	
18 hr, 4°C	1 hr, 36°C, with cofactors*	1:600	77
3 hr, 36°C	None	< 1:20	
3 hr, 36°C	1 hr, 36°C, with cofactors*	< 1:20	0

* The cofactor mixture contained a final concentration of diphosphopyridine nucleotide (0.33 mg/ml), adenosinetriphosphate (0.33 mg/ml), coenzyme A (0.44 mg/ml), and glutathione (3.3 mg/ml), suspended in basal medium.

or 4°C, and samples were removed at the times indicated in Table 1. The rickettsiae were sedimented by high-speed centrifugation in the cold, and the sediments were extracted first in the cold and subsequently at 90°C with 5 percent perchloric acid. Supernatants, made 5 percent with respect to perchloric acid, and cold and hot perchloric acid extracts of the sediments were subjected to spectrophotometry and chemical analysis. All spectra (230 to 300 mμ) showed sharp maxima at 260 mμ.

The results indicate that at 36°C the progressive appearance of 260-mμ-absorbing materials in the suspending medium was matched by a complementary decrease in the nucleic acid (hot 5 percent perchloric acid) fraction. This effect was much less pronounced at 4°C. While incubation at 36°C had little effect on the quantity of material in the cold perchloric acid extracts, it appears that, at 4°C, some of the material derived from the nucleic acids was retained in this fraction. The sums of the three fractions remained constant for the duration of the experiment.

Rickettsial suspensions which had lost toxicity for mice through incubation at 4°C for 18 hours were readily reactivated in a manner similar to that described by Bovarnick (*1*). In contrast, rickettsiae which had been incubated at 36°C for as short a period as 3 hours could not be reactivated by the same procedure. Rickettsial inactivation thus appears to be a complex phenomenon which not only involves the reversible depletion of DPN but may include among other factors the irreversible loss of nucleic acids from the organisms. (See Table 2.)

Ribose and DNA analyses indicated that RNA comprised 75 percent of the nucleic acid components lost by the rickettsial cells. Previous failures to detect RNA in rickettsiae have been ascribed to the loss of this constituent

during purification (*10*). Indeed, the low RNA/DNA ratio (1:3) reported by Smith and Stoker (*11*) for *Coxiella burnetii* may reflect such losses and suggests the physicochemical lability of rickettsial RNA.

The differences between the results obtained at 36°C and at 4°C suggest the participation of enzymatic processes in the loss of nucleic acids from the rickettsiae. Since the omission of glutamic acid did not influence the experimental results, "energy metabolism" does not seem to be of importance. The present findings are perhaps analogous to the degradation of RNA in resting cultures of *Escherichia coli* H, which has been reported by Stephenson and Moyle (*12*).

The loss of nucleic acids from *R. mooseri* upon incubation at 36°C may be one of the reasons for the concomitant inactivation of the biological properties of this organism.

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4 October 1957

Barium-140 Radioactivity in Foods

We wish to report the presence of the fission products barium-140 and lanthanum-140 in certain foodstuffs in the United States during periods of nuclear weapons tests. The presence of these nuclides in the amounts observed in no way constitutes a hazard; it carries none of the potential implications associated, for example, with strontium-90. It is of practical concern primarily to those engaged in measurements of radioactivity near the natural levels, and when an accurate summation of total radiation is desired. As in the case of cesium-137 (*1*), measurements of barium-140/lanthanum-140 may also be of value in the study of the fallout process.

Barium-140 has a half-life of 12.8 days, and its daughter lanthanum-140 has a half-life of 40.2 hours. Because of their somewhat similar biochemistry and the short half-life of lanthanum, secular equilibrium is likely to be maintained in biological systems, and both nuclides will follow the chemistry of barium. The biochemical behavior of barium-140 is similar to that of calcium and of strontium-90, but the short half-life of barium-140 and the larger biological discrimination factors against it render it potentially much less dangerous than strontium-90.

The presence of barium-140 was first noted in some deer in New Mexico during the summer of 1956—presumably the result of the United States nuclear test Operation Redwing. It was detected and identified (by its half-life) by means of the Los Alamos human counter (*2*), a large 4π liquid scintillation counter designed especially for the measurement of radioactivity at natural levels in people and foodstuffs. A threefold increase was noted in the gamma activity in the spectral region from 1 to 2 Mev (normally potassium-40 only). This corresponds roughly to a barium-140 activity of 0.03 μc per 70 kg, which is 6 percent of the maximum permissible amount for man, on the basis of the "large population" value (*3*). A cow taken directly from the New Mexico range showed a similar amount of barium-140, but commercial beef did not, perhaps because of different feeding habits or because of the time lag between slaughtering and the appearance of the meat on the retail market. While the apparent potassium-40 activity of milk samples showed a few instances of slight increases during 1956, it was not possible to identify the excess activity.

Barium-140 appeared in several United States milk samples during the months of June, July, and August, 1957, presumably as a result of distant fallout from the test operation in Nevada, Operation Plumb-bob, and perhaps from test operations of the U.S.S.R. Identification of the excess activity in the potassium region of the spectrum was again possible on the basis of the measured half-life. Confirmation of the assignment of the activity to barium-140 was obtained by spectral analysis, for which an 8- by 4-inch sodium iodide crystal in a steel room similar to the installation developed by Marinelli and his coworkers at the Argonne National Laboratory (*4*) was used. All five of the prominent barium-140/lanthanum-140 gamma peaks were identified.

Table 1 summarizes dates and concentrations of barium-140 in powdered milk for those locations at which the barium-140 gamma activity exceeded that of natural potassium-40. While detectable increases in activity in the upper energy

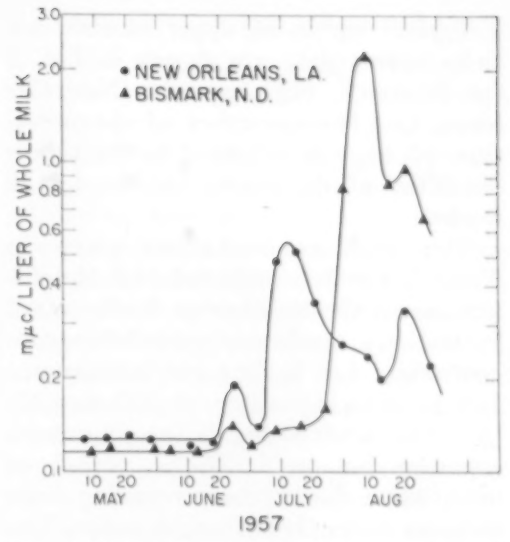

Fig. 1. Typical curves of upper channel activity versus date, for Bismarck, N.D., and New Orleans, La.

channel occurred at other sampling points during the summer months, at none of them did the increase reach this level. Thirty-seven points are routinely sampled.

The dates reported in Table 1 are those on which the samples (50 to 100 pounds of nonfat-dry milk solids) were received at Los Alamos. In general, the delay between production and arrival is about 1 week, and for accurate correlation with meteorological data, the actual production date must be ascertained.

Table 1. Barium-140 peak levels in milk.

Date received (1957)	Estimated barium-140 content (mμc/lit of whole milk)
Bismarck, N.D.	
7 Aug.	2.2
20 Aug.	0.85
Idaho Falls, Idaho	
10 June	0.40
5 Aug.	0.32
26 Aug.	0.54
Payette, Idaho	
19 June	0.12
9 Aug.	0.46
Louisville, Ky.	
21 July	0.27
9 Aug.	0.46
New Orleans, La.	
15 July	0.36
20 Aug.	0.19
Willows, Calif.	
10 June	0.31
Ladysmith, Wis.	
16 Aug.	0.23
Des Moines, Iowa	
9 Aug.	0.18
Ogden, Utah	
19 June	0.06
14 Aug.	0.15
Monroe, Utah	
11 June	0.09
25 July	0.12

Typical curves of upper channel activity versus date are shown in Fig. 1 for Bismarck, N.D., and for New Orleans, La. The constancy of the potassium-40 assay is indicated by the reproducibility of the results for the first 6 weeks.

The peak concentrations given in Table 1 can be compared with the International Commission on Radiological Protection's maximum permissible concentration for barium-140/lanthanum-140 in drinking water of 300 mμc/lit (*3*). The latter value is for continuous exposure for an indefinite period of time, while the exposure resulting from weapons testing is of short duration. Unlike strontium-90, barium-140 cannot present a cumulative hazard because of its very short half-life. Barium-140 has not been observed in any human subjects, although a search has been made for it.

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28 October 1957

Action of Blood-Borne Gamma-Aminobutyric Acid on Central Synapses

When substances are identified in the brain, it is natural at the same time to inquire into their function. Thus they become candidates for various roles, including that of potential neurohumoral transmitters. Such, indeed, has been the case with serotonin (*1*), and such is now the case with gamma-aminobutyric acid (GABA). Bazemore, Elliott, and Florey (*2*) have identified the latter as an active principle of factor I, which Florey and McLennan (*3*) had extracted from mammalian brain and had shown to have inhibitory actions.

One of the readiest methods of acquiring preliminary information of this sort is to paint a solution of the material upon the exposed cerebral cortex. The high doses thus applied and the unusually high concentration gradients that result serve to uncover any possible actions. Effects achieved in this highly abnormal way are undeniable but difficult to interpret in terms of physiological function, even when specificity can be asssured. Although the usefulness of this method, as in the topical application of strychnine (*4*) to fire brain areas, in order to map them, has gained it considerable respectability, this should not be extended to other uses. Thus, Kato (*5*), in studying conduction in nerve, found it convenient to make use of mechanical stimulation by a miniature mallet, but there was no suggestion that this was a normal way to activate or that this mechanical stimulus played a part in propagation of the nerve impulse. Nevertheless, the actions of GABA have been studied almost exclusively by topical application.

We have, therefore, wished to study the effects of blood-borne GABA and have resorted to the method we have previously used to help establish the roles of acetylcholine, adrenaline and nor-adrenaline (*6*), and serotonin (*1*) as neurohumoral transmitters in mammalian brain. This has been the relatively close arterial injection in the common carotid artery serving effectively to bring across the blood-brain barrier relatively small doses which, therefore, on dilution in the systemic blood stream become subthreshold for peripheral actions and consequently exhibit the cerebral actions in isolation or in relatively pure form—that is, not complicated by the peripheral actions and the resulting barrage of afferent impulses which bombard the brain. In this manner, by activating cortical synapses through the transcallosal pathway and recording the response as evoked cortical potentials in the lightly anesthetized cat, we have demonstrated that GABA, when delivered through the natural route (that is, when it is blood-borne), can, like adrenaline, nor-adrenaline, and serotonin, inhibit synaptic transmission. It does this in doses of 50 to 500 μg/kg (Fig. 1); thus it has a potency of about 1/50 that of serotonin, intermediate between that of nor-adrenaline and adrenaline, the series being nor-adrenaline, 1; GABA, 7×; adrenaline, 15×; serotonin, 300×. Unlike the effects of topical application reported by Purpura and Grundfest (*7*) the surface negative evoked response is usually reduced without affecting the positive wave or inverting the negative wave into a positive one.

Comparison with serotonin brings out further significant differences. The time course of the GABA action is faster in all respects. As the continuous plot of the surface negative evoked responses shows, the time of onset and the duration of action are remarkably short. The latter suggests an enzymatic destruction of GABA as was supposed by Florey and McLennan (*3*) or a binding into an inactive state by adsorption as believed by Elliott (*8*). Successful interference with this enzymatic or this binding process would result in abnormal accumulation of GABA, which would be evi-

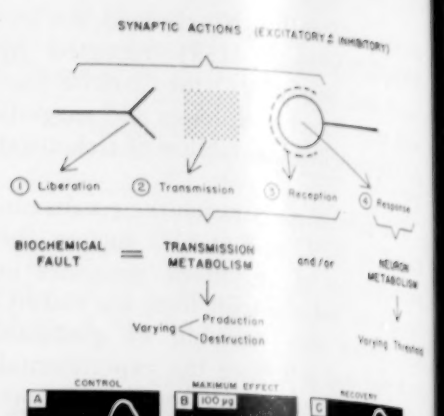

Fig. 1. Cerebral synaptic action of gamma-aminobutyric acid in a two-neurone intercortical (transcallosal) system. (Top) Potential factors in disturbed synaptic equilibrium. (Bottom) Potentials evoked in the cerebral cortex of the cat by electrical stimulation of the contralateral cortex every second. Gamma-aminobutyric acid was injected into the ipsilateral common carotid artery.

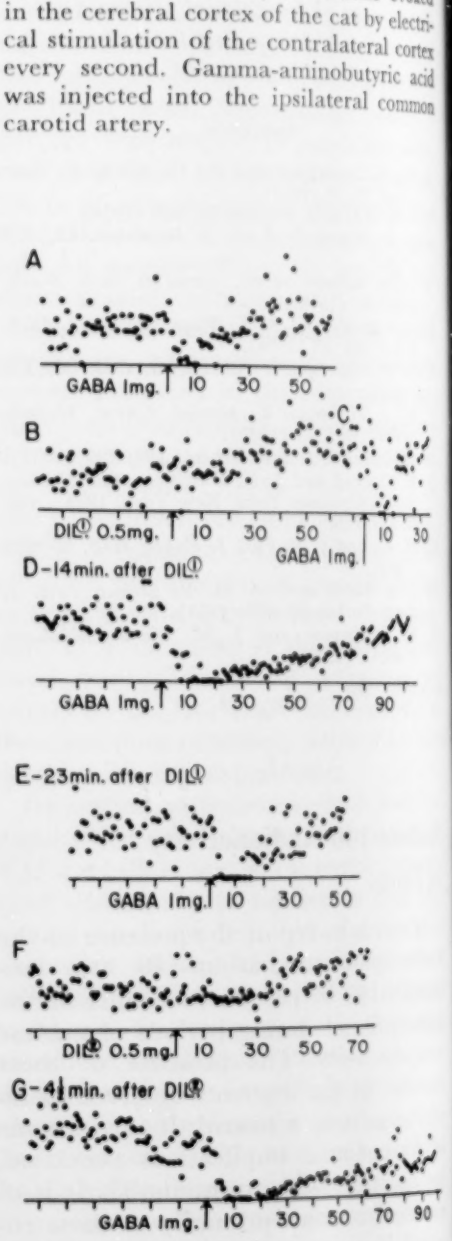

Fig. 2. Augmentation of GABA cerebral synaptic inhibition by dilantin. Negative cortical spike heights from transcallosal system potentials evoked by contralateral cortical stimulation (one per second). Injections were made into the ipsilateral common carotid artery.

denced by a prolongation of the duration of action. We would hope, in this way, also to accumulate naturally present GABA to threshold levels, which would then be recordable as synaptic inhibition.

On the basis that any alteration of GABA might be enough to terminate its inhibitory action, we attempted to interfere with its transamination with alpha-ketoglutaric acid. We have utilized *p*-benzoquinone, which is cited by Braunstein (*9*) as being a highly potent transaminase inhibitor against glutamic aminopherase, but we have been unable to alter the course of GABA effects in this way.

Meantime, because of the long-entertained possibility that events in the glutamic acid–gamma-aminobutyric acid equilibrium might play a role in altered excitability states of the brain and abnormalities—for example, in epilepsy—Woodbury (*10*) had examined the influence of diphenylhydantoin (dilantin) on GABA metabolism and had found in preliminary work that it increases the GABA content of cat brain. We therefore sought to prolong the GABA effects with dilantin. Figure 2 illustrates that we have succeeded in doing just this with intracarotid doses of dilantin having, per se, no effect on synaptic transmission. In fact, the prolongation starts only after a latent period, so that the effect of GABA introduced immediately after dilantin is not prolonged, but a test dose several minutes later does show a prolongation that persists in repeated trials over many minutes.

Perversion of GABA formation or destruction hypothetically constitutes one of the possible biochemical faults diagrammatically indicated at the top of Fig. 1, pointing out the potentially disturbed factors which might be the cause of synaptic dysequilibrium. If GABA is to be considered as a transmitter, then we may say further that it does not act at the same inhibitory receptors as serotonin, since we can effectively prevent or block the synaptic inhibitory action of serotonin with chlorpromazine but cannot similarly block that of GABA. Though not as potent as serotonin, GABA is of great interest because it is even more plentiful in the brain than serotonin and because its site of action is evidently not identical to that of serotonin (*11*).

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22 October 1957

Use of Charcoal to Separate Mixtures of Inorganic, Ester, and Nucleotide Phosphates

Several years ago, the use of charcoal for the separation of inorganic and nucleotide phosphorus fractions, with particular application to experiments involving radioactive phosphorus, was described (*1*). Briefly, the procedure called for the addition of charcoal to a trichloroacetic acid extract containing inorganic and nucleotide phosphorus, the removal by centrifugation of the charcoal with its adsorbed nucleotide, and heating of the charcoal suspended in acid solution to release the nucleotide phosphorus as inorganic phosphate. This procedure has been accepted and used routinely in a number of laboratories in spite of the limitation that the nucleotide is not recovered in substance.

In this laboratory, charcoal has been used principally for the removal of nucleotide from mixtures in which phosphate esters have been prepared by means of the hexokinase reaction (*2*). In the course of these experiments, it was found that the use of hydrochloric acid in place of trichloroacetic acid to terminate the reaction resulted in the loss of ester by its adsorption to the charcoal (*3*). Recent experiments on the adsorption of nucleotide by charcoal have led to the finding that desorption can be accomplished by suspension of the charcoal in trichloroacetic acid (TCA) to which has been added the ammonium salt of trichloroacetic acid. These observations are substantiated by the data of Table 1.

The experiments were carried out as follows: Five milliliters of a solution containing 1 μmole per milliliter each of inorganic phosphorus and of one of the phosphate esters shown in Table 1 were placed in a centrifuge tube. To this was added 0.05 ml of 5*N* hydrochloric acid and 0.3 g of acid-washed (*3*) Norit-A charcoal. The contents of the tube were mixed by inversion, 0.01 ml of 10 percent Triton X-100 (*4*) was layered on top to reduce the amount of charcoal which floats, and the tube was centrifuged. The supernatant solution was decanted and assayed for inorganic and total phosphorus by the method of Fiske and Subbarow (*5*). The charcoal was extracted twice with 5 ml portions of 0.05*N* hydrochloric acid by suspension and centrifugation and once with 4 ml of 10 percent trichloroacetic acid. The trichloroacetic acid extract was assayed for total phosphorus. The results of this experiment are given in the first two columns of Table 1.

A similar experiment was carried out with adenosine triphosphate and inosine triphosphate without the addition of inorganic phosphate. The charcoal, after the washing with 10 percent trichloroacetic acid, was suspended in 4 ml of 25 percent trichloroacetic acid, and a solution of ammonium trichloroacetate (prepared by the addition of 8.3 ml of 28 percent NH_3 to 20 ml of 100 percent trichloroacetic acid) was added to a final volume of 10 ml. The charcoal was mixed in by inversion and shaking and removed by filtration. The nucleotide in the various fractions was assayed by phosphorus analysis (*5*) of aliquots subjected to heating at 100°C in 1*N* sulfuric acid for 11 minutes (*6*). The results of this experiment are shown in Table 1.

These experiments show that it is possible, by the use of Norit-A charcoal, to

Table 1. The adsorption of inorganic, ester, and nucleotide phosphates by acid-washed Norit-A charcoal. TCA is an abbreviation for trichloroacetic acid. The concentrations of these solutions are given in the text. The percentage desorbed is calculated on the basis of the amount adsorbed, not on the amount in the original solution.

Compound	Adsorbed from 0.05*N* HCl (%)	Desorbed in TCA (%)	Desorbed in TCA–NH_4TCA (%)
Inorganic ortho-P	8.4		
Adenosine tri-P	100	< 1	91
Inosine tri-P	100	31	60
Glucose-6-P	91	97	
Galactose-1-P	96	100	
Mannose-6-P	93	88	
Galactose-6-P	91	92	
Fructose-6-P	92	100	
1,5-Sorbitan-6-P	96	100	
Fructose-1,6-diP	97	95	
Glucose-1-P	97	81	
Ribose-5-P	100	75	
L-Sorbose-1-P	97	72	
2-Deoxyglucose-6-P	100	53	
Glucoheptulose-7-P	77	83	

separate mixtures of inorganic, ester, and nucleotide phosphates and to recover each of these in substance. The application of this information will, of necessity, be an individual one, and it seems not worth while to recommend a specific procedure of limited application. It must be kept in mind that differences in the degree of adsorption and desorption of esters and nucleotides as observed here will be encountered, and control experiments will be required (*7*).

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21 October 1957

Exploration of Electronic Methods for Evaluating Sperm Motility

The growth of artificial insemination of cattle during the past 10 years has emphasized the need for adequate methods of predicting the fertility of semen samples before they are used. Laboratory studies and field operations have relied heavily on visual estimates of sperm numbers and sperm motility. These estimates have been continuously subject to the unavoidable human errors and biases encountered in collecting quantitative data with the microscope. A number of objective methods have been proposed for evaluating sperm motility (*1–3*). These methods have made use of the relationships among sperm numbers, area observed, distances traveled, and the time intervals between or during the observations. The objections to these methods have included such items as the need for standardization of the sperm numbers, the laborious and time-consuming techniques and calculations, the human bias, and the repeated high costs of the determinations.

The ideal method of evaluating sperm motility should include means of determining directly or indirectly (i) the total numbers of sperm per unit volume, (ii) the number of motile and the number of nonmotile sperm, (iii) the mean speed of motility displayed by the moving sperm, and (iv) the distribution of the total sperm with regard to kind and speed of motility.

A number of electronic methods have been proposed for making biological measurements (*2, 4*). Some of these methods have involved the quantitative measurement of some characteristic of a microscopic field by scanning techniques. Preliminary attempts at using such techniques for evaluating spermatozoa are reported here. Two principal assemblies of equipment have been utilized. The first of these was a model TA-124E Image Orthicon television camera chain, in which a type 58-20 Image Orthicon pick-up tube and a single-line selector were used to observe the oscillographic display resulting from single cells in the field. The second assembly consisted of a single, stationary multiplier phototube viewing a restricted portion of the microscopic field with the sperm cells rendered bright in a dark field either by dark-field illumination or by fluorescent staining and ultraviolet illumination (*5*). Impulses from the multiplier photocell were displayed oscillographically (with a triggered 1-second sweep and an a-c coupled vertical amplifier) and counted with a preset counter.

With the television camera chain assembly, the determination of the total numbers of cells in an optical field may be accomplished by relatively simple scanning techniques which will count the total particles in the field (*6*). Two fluorescent dyes, Coriphosphin and Euchrysin 2 at nontoxic levels varying from 1:1000 to 1:100,000, were used to stain the sperm and helped to eliminate the counting of particles of extraneous material such as fat globules in the milk used as a protective diluent (*7*). Exposure to the near ultraviolet light emitted by the high-pressure mercury vapor lamp (AH6) used had to be limited to avoid heat and radiation injury to the sperm.

The moving sperm could be detected by the single line selector as they crossed the single scan line. The counter was preset to record only the maximal impulses which were caused by the passing of the sperm head. An example of the oscillographic display caused by a fluorescent-stained sperm crossing the single scan line is shown in Fig. 1*A*.

With the previous knowledge on total numbers of sperm present and with the information obtained on the number of sperm that pass the scan line in a given interval, the average speed for all sperm of the sample (including nonmoving sperm) can be calculated. Added information on the percentage of sperm moving would be necessary to determine the average speed of the motile sperm. With the use of more complicated electronic equipment involving a guard spot or memory circuits, which would differentiate between counts of moving and nonmoving sperm, the same equipment could be adapted to determine the percentage of motile sperm.

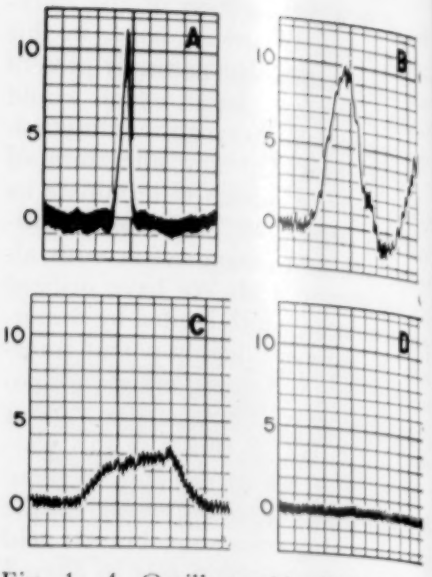

Fig. 1. *A*, Oscillographic display caused by fluorescent-stained sperm crossing a single scan line. *B*, *C*, *D*, Oscillographic patterns produced by dark-field illumination of sperm passing an aperture by swimming rapidly, swimming slowly, and by drifting, respectively.

A second attempt at evaluating sperm motility was made with the television camera chain by scanning an area of cell-free plasma into which sperm cells were allowed to migrate. The cells were either centrifuged to bring them down to an initial starting point or were allowed to migrate out of the opening of a stopcock into the plasma. The concentrated cells formed an opaque mass, and their migration into the plasma was easily followed by scanning the mid-section of the area with a single-line selector. The results obtained with this procedure were promising and suggested that refinements of the technique and the use of a lens system to magnify the field would add to the precision of the method.

When the secondary assembly of equipment was used, the multiplier phototube was placed so that it would pick up the image of a single sperm head as it passed an aperture. The impulse generated by the dark-field image of a sperm was counted in a manner similar to that used in the apparatus first described. In addition to counting the motile sperm which passed the aperture, it was possible to determine the kind of motility being displayed by a particular cell. Rapidly moving sperm which were exhibiting the normal helicoidal pattern of movement produced a sharp peak in the oscillographic sweep (Fig. 1*B*). A slowly rotating sperm produced a broad peaked sweep (Fig. 1*C*).

Oscillating sperm that were not rotating did not cause peaks in the horizontal sweep of the oscillograph (Fig. 1*D*).

Although the method in which the multiplier photocell was used gave the clearest recording of the type of sperm activity that was occurring, it did fail to give a measure of the total number of sperm present. This might be overcome by means of a mechanically operated stage which would permit counting the sperm in a known area of the slide by scanning with the multiplier phototube.

While none of the methods tried thus far have given results which approach the ideal for evaluating sperm motility, all the methods show considerable promise and are being investigated further. Relatively complex equipment was used for these tests as a matter of expediency. Simplified equipment to accomplish the same purposes is being assembled.

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11 October 1957

Analysis of Small Amounts of Fatty Acids

A recent note by C. M. Coleman and G. Middlebrook (*1*) describes a new method for estimating small amounts of fatty acids. The authors claim that their method is the best described to date. The purpose of the present note is to draw the attention of the authors and of others working with fatty acids to a widely applicable general method published last year (*2*). In this method, as in that of Coleman and Middlebrook, ionic dyes of opposite charge to large organic ions are used in a two-phase system, consisting of water and an organic liquid. Unlike the method of Coleman and Middlebrook, in which use is made of the interfacial enrichment of the dye, this method makes use of the preferential partition of the stoichiometric simple salts that dyes form with large organic ions (*3*) into the organic phase. This makes the method an equilibrium method, in contrast to that of Coleman and Middlebrook. The method is, moreover, considerably more sensitive and accurate than that of Coleman and Middlebrook. For lauric acid, for example (a system for which their method did not give any result), estimation as the sodium salt of about 20 mμmole to approximately 1-percent accuracy can be carried out through the use of pinacyanol under proper conditions (*2*).

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19 August 1957

We wish to thank Mukerjee for having called his paper of 1956 to our attention. At the time of submission of our paper for publication in *Science*, reference to Mukerjee's work had not yet been indexed under a subject heading in *Chemical Abstracts*, and, consequently, we missed the original publication.

We have tried Mukerjee's method and agree with him that it is an excellent method not only for measuring small amounts of long-chain fatty acids but for measuring many other ionic surfactants. We would like to point out, however, that our method, in our experience, is more specific for the analysis of long-chain fatty acids in mammalian blood and tissue lipids. For example, phospholipids do not interfere with the determination of long-chain fatty acids in our method.

Our ignorance of Mukerjee's work very aptly points up the need for more prompt and efficient centralized transfer of information between investigators.

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22 October 1957

An Enzymatic Basis for the Gluconeogenic Action of Hydrocortisone

The pronounced effects of cortisone and related steroids on carbohydrate metabolism appear to be due to their activity on hepatic gluconeogenesis rather than on the peripheral utilization of glucose. However, the biochemical mechanisms mediating the gluconeogenic action of these compounds are not known. Recently, Gavosto *et al.* (*1*) suggested that cortisone increases gluconeogenesis and imposes a negative nitrogen balance by enhancing transamination processes. They observed that near-toxic doses of cortisone (120 mg/kg), when administered to rats for 3 days, increased the activity of glutamic-oxalacetic transaminase (GOT) by 67 percent and that of glutamic-pyruvic transaminase (GPT) by 81 percent in liver. Independently, in the course of studies on the effect of hydrocortisone on enzymes which require pryidoxal phosphate as a cofactor, we have noted as much as 500 percent increase in the GPT activity in livers of rats treated with hydrocortisone, whereas, under the same conditions, the values for GOT were only slightly higher than those of the untreated control animals.

Male albino rats (Holtzman) weighing from 125 to 150 g were used. The methods of Lowry and co-workers for GOT (*2*), lactic acid dehydrogenase (*3*), and protein (*4*) were used. The method used for GPT (*5*) is based on the same principle as that of Wroblewski and LaDue (*6*), except that instead of measuring spectrophotometrically the disappearance of reduced diphosphopyridine nucleotide (DPNH), the DPN formed is determined fluorometrically (*3*). Tissues were kept at 0°C until they were homogenized and assayed. These enzymes were found to be stable during storage at −20°C in the 1 to 20 homogenates of brain and liver.

The marked rise in GPT activity, in contrast to the activity of GOT, in the liver of rats receiving hydrocortisone, is shown in Table 1. Lactic acid dehydrogenase (LDH), an enzyme which does not require pyridoxal phosphate, was not affected by treatment with hydrocortisone. Similar analyses of whole brain from the same animals revealed less than 20 percent increase in GPT activity and no significant changes in GOT and lactic acid dehydrogenase values associated with treatment. When pyridoxal phosphate was added to the complete system for each transaminase, no stimulatory effect could be detected. It was also noted that the addition of hydrocortisone in vitro to the GPT homogenate system did not enhance the activity of this transaminase.

In an earlier experiment with pyridoxine-depleted rats, GPT values ranging from 500 to 700 percent above normal were observed after 4 weeks of treatment with 5 mg of hydrocortisone per rat per day. In the studies summarized in Table 1, the GPT levels were doubled after 2 days of treatment, and maximum GPT activity in liver occurred after the seventh day of treatment with 2.5 or 5 mg of hydrocortisone per day. Although some variation in the control values for GPT was noted on different days of the experiment, the standard deviation of each group remained small. On the 28th day, 14 days after the administration of hydrocortisone was discontinued, the GPT activity was still considerably higher than normal. Whether this observation can be attributed to the normal turnover rate of this enzyme in liver, or to the prolonged retention of hydrocortisone or an active metabolite, cannot be answered at this time.

The administration of large amounts of pyridoxine to animals receiving hydrocortisone did not alter the magnitude of the GPT response. Furthermore, depletion of rats of pyridoxine for 8 weeks did not impair the increase in GPT following daily injections of hydrocortisone (5 mg) for 1 week. Thus, neither depletion of pyridoxine nor administration of this vitamin appears to affect the changes in hepatic GPT levels produced by hydrocortisone.

Table 1. Effect of two levels of hydrocortisone on glutamic-pyruvic transaminase (GPT), glutamic-oxalacetic transaminase (GOT) and lactic acid dehydrogenase (LDH) activities of rat liver. There were 20 animals in each group; five animals sacrificed on days 2, 7, 14, and 28. The animals were maintained on Purina mouse diet. The weight of rats in the untreated group was controlled during days 1 to 14 by restricting diet; thereafter, the rats were allowed to eat *ad libitum*. Hydrocortisone was injected subcutaneously (2.5 and 5.0 mg per rat per day). The administration of hydrocortisone was discontinued on day 15. The animals were killed by severance of the carotid artery and were exsanguinated before the tissues were removed.

Hydrocortisone treatment (mg)	Enzyme activity (mmole of substrate utilized/g of protein, per hour at 38°C)		
	GPT	GOT	LDH
	Second day		
0	12.1 ± 3.2*	107 ± 10	281 ± 12
2.5	18.9 ± 2.0	112 ± 9.2	271 ± 12
5.0	25.4 ± 3.4	103 ± 5.2	259 ± 9.0
	Seventh day		
0	8.7 ± 2.9	128 ± 3.6	290 ± 19
2.5	44.7 ± 4.1	140 ± 8.9	277 ± 33
5.0	53.0 ± 5.1	157 ± 3.9	268 ± 19
	Fourteenth day		
0	16.1 ± 1.8	122 ± 13	266 ± 6.0
2.5	66.4 ± 4.4	152 ± 5.8	247 ± 25
5.0	71.0 ± 2.3	142 ± 14	242 ± 24
	Twenty-eighth day		
0	17.5 ± 2.0	143 ± 6.8	299 ± 16
2.5	30.3 ± 4.3	157 ± 2.8	246 ± 16
5.0	52.5 ± 2.0	172 ± 7.7	226 ± 14

* Standard deviation = $(\Sigma d^2/n)^{\frac{1}{2}}$.

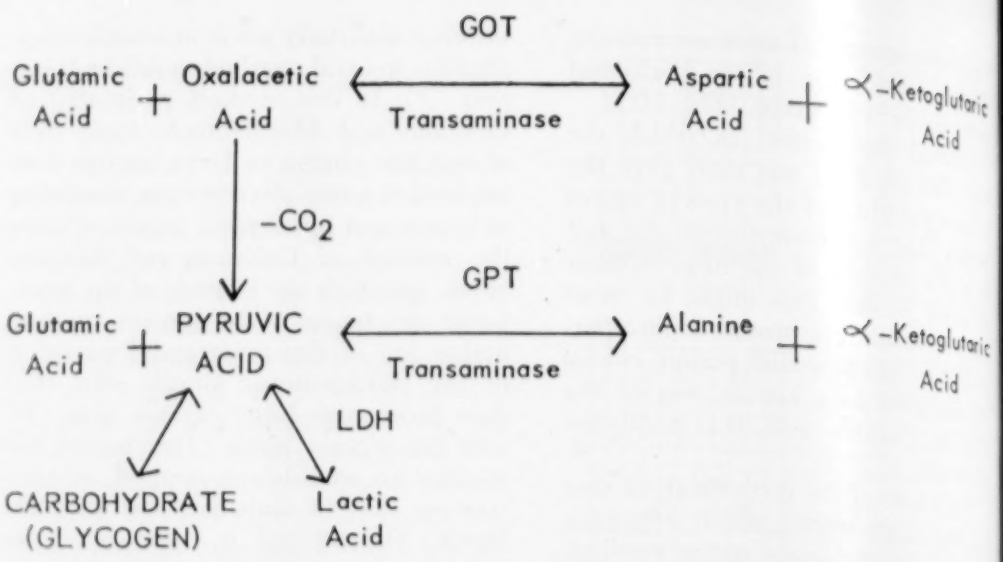

Fig. 1. Transaminase reactions and pathway to carbohydrate synthesis.

It was of interest to determine whether other corticosteroids increased hepatic GPT activity to the extent observed with hydrocortisone. The daily subcutaneous injection of rats with Prednisone (2.5 mg) or cortisone acetate (5 mg) for 1 week resulted in more than a five-fold increase in liver GPT activity in each case. In a comparable experiment, deoxycorticosterone was administered (3 mg daily); the hepatic GPT values were not increased, and they appeared to be somewhat lower than those of the untreated control animals. The relationship between the stimulation of hepatic GPT activity and the gluconeogenic potency of related steroids is under study to evaluate the hepatic GPT response to corticosteroids as a method of assay.

Negative nitrogen balance is also an important aspect of treatment with glucocorticosteroids. These studies do not indicate whether the effect of hydrocortisone is limited to alterations in GPT activity or whether transamination processes other than GOT are also affected. It is apparent, however, that increased transaminase activity can be related directly to amino acid imbalances which initiate protein catabolism and negative nitrogen balance.

Of the many amino acids which have been studied for gluconeogenic activity, alanine, aspartic acid, and glutamic acid are unique with regard to their high gluconeogenic potency (*7*). The relationship between the substrates in the transaminase reactions studied herein and the pathway to carbohydrate synthesis is shown in Fig. 1. Pyruvic acid appears to be the common intermediate in the conversion of these amino acids to glycogen. Both pyruvic acid and lactic acid are readily converted to carbohydrate. Moreover, both of these metabolites occur in elevated concentrations in the blood of patients with Cushing's syndrome and in subjects receiving glucocorticosteroids (*8*). These facts, added to the observation that a substantial rise in hepatic GPT occurs in rats treated with hydrocortisone, in contrast to treatment with deoxycorticosterone, strongly suggests that the control of hepatic levels of GPT by glucocorticosteroids is importantly related to the mechanism whereby these compounds exert their gluconeogenic activity (*9*).

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30 September 1957

Corrosion of Pure Aluminum and Tin in Salt Spray

Despite the widespread and continued use of the salt spray test as a specification for plated metal parts (*1*) and as an accelerated corrosion test (*2*), very little is known about the actual mechanism of corrosion under these conditions. In

recent work on tin-plated copper (*3*) it was found that the rate of corrosion in salt spray could be expressed by an equation of the form

$$C = Kt^n + b$$

where t is the time of exposure. It was not known, however, whether the observed rate was that of pure tin or whether the rate was influenced by the copper substrate. The latter situation would imply the existence of a galvanic couple in which the tin was anodic.

The technique described in this report was developed in order to study the corrosion of thin metallic films on a relatively inert substrate (*4*). It is believed that it can be used as a simple, inexpensive technique for measuring corrosion rates in a wide variety of environments.

Aluminum and tin films were evaporated onto cleaned glass slides, 2 by 2 in., by means of conventional high-vacuum techniques (*5*). The light transmission was determined for the central square inch by mounting the glass in aluminum slide-holders and by using an ordinary 35-mm slide projector. The projector had been modified so that the light path was enclosed by an opaque tube, and the lens position had been changed so that the image of the slide was focused onto a ground-glass screen just in front of a 931A photomultiplier tube. The output of the tube was read by a microammeter, and the intensity of the light was adjusted to give 100 percent transmission for holes of known diameter drilled into brass plates.

After measurement of the light transmission had been made, the specimens were removed from the aluminum holders and placed in a Lucite rack designed to hold them at the recommended angle of 15 degrees from the vertical. They were then placed in a standard salt spray test cabinet operating at 95°F (*1*); a 4 percent NaCl solution was used. When 4 hours had elapsed, the samples were removed, washed with cold water and alcohol, then dried, and the light transmission was determined. The procedure was repeated for as long as practical.

The results for tin and aluminum are shown in Fig. 1. Each graph represents the weighted average (with allowance made for the variation in individual

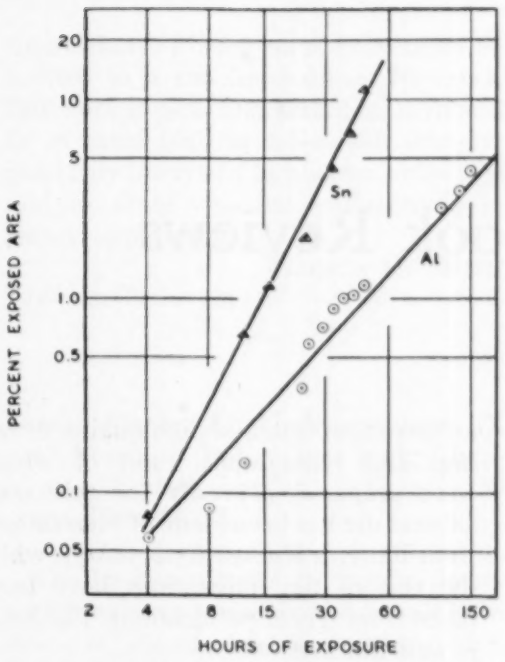

Fig. 1. Log-log plot of the corrosion of thin aluminum and tin films on glass: hours of exposure to 4 percent sodium chloride spray versus percentage of metal areas exposed.

thicknesses) of ten samples. The data are plotted as the logarithm of percentage transmission (compared to the total area) versus the logarithm of hours of exposure to salt spray. As can be seen, the corrosion rate for aluminum appears to have a slope of 1, and that for tin, a slope of 2. This means that the data may be represented by

$$C_{Sn} = Kt^2 + b$$
$$C_{Al} = K't + b'$$

where C_{Al} and C_{Sn} are the exposed areas resulting from corrosion and t is time of exposure.

Gross examination of the tin specimens indicates that corrosion occurs by pitting. If the attack of a salt solution is linear with time, then the exposed area would increase at the square of the rate of increase of the radius of the pit. Since the corrosion as measured by light transmission is total exposed area, the actual corrosion in one dimension is probably linear with time. The agreement in rate for thin tin films on copper and glass suggests that the same mechanism is operative in each case and rules out mechanisms involving the substrate material.

Since the corrosion of tin proceeds as the square of the time of exposure, great caution must be exercised in expressing corrosion rate data in standard terms, such as inches per year or milligrams per decimeter per day (*6*).

For aluminum, the results indicate that no protective film is formed under salt spray conditions. It is not known whether this is due to the attack by the primary corrosion products, as suggested by Schikorr (*7*) for sodium chloride solutions, or due to the ability of the chloride ion to penetrate the oxide coating. The results are in agreement with those of Champion (*8*), who measured hydrogen evolution and oxygen absorption for aluminum suspended in potassium chloride solution. He found a curve of the form

$$dC/dt = \alpha C + \beta$$

although the values of the constants changed several times over a period of 40 days.

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9. The help of Harold Woolley in the design and construction of the equipment, and the technical assistance of Claire Maier and Anna Imswiler, are gratefully acknowledged.

28 October 1957

Book Reviews

Essentials of Human Anatomy. Russell T. Woodburne. Oxford University Press, New York, 1957. viii + 620 pp. Illus. $12.50.

It is not often that one has an opportunity to read a refreshing book in the field of human gross morphology. Woodburne's *Essentials of Human Anatomy* is one such book, and it will, I am sure, revitalize the regional approach to the study of human morphology. The need for such a book becomes evident with the increasing pressures for knowledge in medicine and with the concomitant compression of the time available for learning the essentials of (in this case) anatomy. Its relative brevity lies in "an adherence to the essentials of morphology presented functionally and concisely."

The text is not intended to be encyclopedic, as are standard anatomy books using the systemic approach. However, some topics are discussed in greater detail than in such books—for instance, the internal segmentation of the liver. More space is devoted to certain anatomical facts which are of more clinical import. Thus, there is an excellent discussion of the cervical fasciae, based on the now classic paper by Grodinsky and Holyoke (1938). In connection with the frequent development of mammary carcinomas and their subsequent metastases, the lymphatic drainage of the gland is emphasized.

In comparison with other books on regional anatomy, *Essentials of Human Anatomy* (i) considers a closer integration of physiology and anatomy, (ii) gives references to new information, (iii) presents much cross-referencing of facts within the text per se, and finally, (iv) uses the anatomical nomenclature adopted by the Sixth International Congress of Anatomists in 1955. The third and fourth points are especially significant, the former because it enables the reader to find further information on a particular point without going to the index, the latter because the changes in terminology that have been adopted are directed toward simplicity, consistency, logic, and elimination of the use of eponyms.

Mnemonics and analogies are used in a way that is reminiscent of another standard text on regional anatomy. There are over four hundred high quality drawings and radiographs, most of which were prepared expressly for this text. Liberal use has been made of illustrations from Patten's *Human Embryology,* while the rest of the illustrations have been taken from recent publications. The book is well indexed.

This text is highly recommended to all who are interested in anatomy.

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The Concept of Development. An issue in the study of human behavior. Dale B. Harris, Ed. University of Minnesota Press, Minneapolis; Oxford University Press, London, 1957. x + 287 pp. Illus. $4.75.

This volume is, in effect, a series of free associations to the term *development* by a distinguished and diversified company of scholars and specialists. Prepared in honor of John E. Anderson, for 30 years director of the Institute of Child Welfare at the University of Minnesota, the volume includes contributions from half a dozen psychologists (Anderson, Harris, Olson, Russell, Sears, and Werner), four biologists (Hamburger, Meredith, Schneirla, and Scott), a philosopher of science (Nagel), a historian (Heaton), a classicist (DeWitt), an anthropologist (Spencer), and three representatives of applied fields—a pediatrician (J. A. Anderson), a psychiatrist (Lippman), and a social worker (Kidneigh).

Free associations, recent research tells us, reveal less of the esoteric than of the everyday concerns of the respondent—what he thinks about and how he thinks about it. So with these essays. We learn, for example, that for the psychologist and biologist, development is a property of living organisms, with the psychologist showing some slight partiality for the human species. The anthropologist, the historian, and the classicist view the process as a characteristic of cultures, periods, or, more generally, phenomena conceived as organic systems. The trend toward abstraction culminates, as one might expect, in the contribution of the philosopher, who attempts a disembodied formulation in terms of stipulated logical relationships among entities designated by letters and subscripts.

Having found the bluebird in his own home territory, how does each specialist view this elusive creature? As is usual with bird-watchers, the view is a distant one, and the principal concern is identification. Most of the essays begin with the problem of definition and many never get beyond it. There are innumerable statements of defining-properties and of distinctions between development on the one hand and growth, change, differentiation, and so forth, on the other. The editor, in his introductory essay, asserts that the volume was planned in the spirit of Dobzhansky's thesis that "generalization and integration can best be made by scientists who are also fact-gatherers, rather than specialists in . . . speculation." There can be no question that, among his contributors, Harris has indeed included a number of distinguished fact-gatherers. But some of them apparently welcomed an opportunity to indulge in theorizing, uninhibited by cantankerous research results. Others who brought their data along, were not in a speculative mood. The editor offers the 17 contributions as "evidence that concepts of development variously conceived are fruitful in research work in many fields and of great value in the study of human behavior." In my judgment, only three essays approach satisfaction of this ambitious criterion—those of Werner, Russell, and Sears. These authors do propose ideas that are translatable into concrete research operations either in the form of new observations to be made or new hypotheses to be investigated. Werner and Sears describe studies from on-going research programs; Russell points to the intriguing problems that confront the experimental psychologist once he forgoes the comfortable assumption that the laws of learning remain constant irrespective of the developmental level of the learner.

Other contributions are noteworthy on other counts. Schneirla presents an excellent survey of the research literature on the development of behavior in animals. Scott and Olson provide convenient integrations of previous research contributions by themselves and their associates. DeWitt puts his scientific colleagues to shame by the clarity and grace with which he exposes the complexities and risks involved in attempting to transfer organic concepts from the field of biology to other realms.

But all these are isolated achievements. As a whole, the volume lacks unity. *The Concept of Development* unfortunately contributes little to the development of a concept.

URIE BRONFENBRENNER
Cornell University

La Chimie Nucléaire et Ses Applications. M. Haïssinsky. Masson, Paris, 1957. 651 pp. Illus. Cloth, F. 5600; paper, F. 5000.

In the case of a rapidly expanding field, up-to-date books are very important, and this one answers that need in nuclear chemistry. Prior knowledge on the part of the reader of the fundamental laws of radioactivity is assumed by the author.

The author points out that his work encompasses a greater field than the title would indicate. He has avoided in the title the use of such expressions as radiochemistry and tracer chemistry. He feels that this semantical approach is the least confusing.

At the risk of contributing to this confusion in nomenclature, I suggest that the book can be somewhat arbitrarily divided into four broad parts. The first eight chapters and one later chapter could be classed as nuclear chemistry and nuclear physics. The chapters which constitute this section are, "A brief history of radioactivity," "Nuclear chemistry and nuclear physics," "Fundamental particles," "The nuclei," "Spontaneous radioactive transformations," "Nuclear reactions," "Nuclear fission and reactors," "The natural radioelements," "The transuranium elements," "Chemical effects associated with nuclear transformations," and "Dissipation in matter of the energy of radiations."

The physical chemistry section includes: "Isotopic effects and separations," "Isotopic exchange," and "Distribution of a micro component between two phases."

The applications of natural and artificial tracers in the following fields are described: astrophysics, geology, and geochemistry; electrochemistry; analytical chemistry; chemical reaction mechanisms; biochemistry, physiology, and medicine; and technical and industrial applications.

The fourth part is devoted to radiation chemistry and radiation physics: chemical actions of ionizing radiations; radiolysis of water and aqueous solutions; radiolysis of organic compounds and biological effects of radiations; actions of radiations on solids; and fluorescence and coloration produced by radiations.

There is no part of the book devoted expressly to chemical separation procedures and techniques. However, this topic is given considerable attention in the sections on nuclear chemistry and physical chemistry.

There are a sufficient number of references to original publications to supplement sections of individual special interest.

In order to discuss all of the topics listed above, a book must necessarily be written in a concise manner. However, this work is clear and readable. It should be of value both to individuals who are primarily interested in nuclear properties and to those who use radioactivity in tracer applications.

WARREN G. SMITH
Indiana University

Linear Algebra for Undergraduates. D. C. Murdoch. Wiley, New York; Chapman & Hall, London, 1957. xi + 239 pp. Illus. $5.50.

Of the many books on matric theory which have appeared in the last decade, few are aimed directly at the undergraduate. This book seems to be so directed. The author states that the only prerequisite to its study are college algebra, including determinants and some knowledge of three-dimensional analytic geometry. However, a little more mathematical maturity would stand the student in good stead, since contact is made with vector analysis, systems of differential equations, and dynamics. These can be by-passed, however, and an appendix of 32 pages gives a good summary of solid analytic geometry.

The approach is by means of vector spaces. The usual elementary properties of matrices are developed, including quadratic form theory with applications to analytic geometry. Elementary divisor theory is entirely omitted, and the space devoted to the similarity of matrices is small.

The book contains relatively few of the concepts of abstract algebra, which I regret, for here is a place in the curriculum where a number of abstract concepts could be introduced, well clothed, in the flesh. Many important concepts are introduced casually in the problems; among these are symmetric, skew symmetric, and nilpotent matrices and the congruence of matrices. But, all in all, this should be a satisfactory text at the level for which it is designed.

C. C. MACDUFFEE
University of Wisconsin

Geologic Field Methods. Julian W. Low. Harper, New York, 1957. xv + 489 pp. Illus. Professional edition, $6; text edition, $4.50.

Prepared for the student or inexperienced field man, this book contains many useful details concerning techniques and methods. Suggestions for the use of the plane table, hints for the preparation of geologic maps, description of work with key beds, instructions for measuring dip and strike and for computing the thicknesses of formations, and directions for making field sketches are among the subjects comprising the ten chapters. The author's selection of topics must have been governed largely by the questions asked repeatedly by the immature field geologist. This book therefore meets a felt need, and I am sure that many teachers will recommend it to their students.

Several of my colleagues who have examined this volume hold the view that the addition of carefully selected bibliographic references would overcome the most serious shortcoming of the book. To this I would add a plea for better English. The monotony, for example, of reading sentence after sentence beginning with "it is" does not add force to the exposition.

This book is a welcome addition to the library of the geologist.

HUBERT G. SCHENCK
Stanford University

Laboratory Glass-Working for Scientists. A. J. B. Robertson, D. J. Fabian, A. J. Crocker, and J. Dewing. Academic Press, New York, 1957. xiv + 184 pp. Illus. $4.

This little volume contains a great deal of valuable information regarding the physical and chemical properties of various glasses used in scientific laboratories and describes in an easily understandable fashion the manipulations of glass that are of most importance to the experimental scientist. Far from trying to teach the skills possessed by professional glass blowers, the authors have emphasized methods which are relatively easy and simple and which, while not necessarily producing the most beautiful result, will enable the reader after some practice to assemble a usable piece of apparatus. Facilities for performing many of the operations and some "tricks" described in this book are not readily available everywhere. A fairly extensive chapter deals with the equipment needed for a glassworking shop, stressing the point that while a great many operations can be carried out with a few primitive tools, it is false economy to waste valuable research time for lack of proper shop facilities. The chapter on basic glassworking operations contains the usual information on bending, joining, and simple blowing procedures; methods for cementing and metalizing of glass are also described. Other chapters deal with the use of glassworking machines, with glass-to-metal seals of various kinds, and with the design of simple and of somewhat more complex pieces of apparatus, like McLeod gauges, diffusion

pumps, Soxhlet extractors, and so forth. Each chapter contains a large list of refrences, which may be very useful when more detailed information is needed.

Written primarily for British readers, the book not only contains information on many kinds of glass rarely seen in the United States but also stresses many precautions which have to be observed in order to handle these glasses successfully. The American reader, who uses Pyrex glass almost exclusively, will be able to achieve many of the same results with somewhat simpler methods. Since, however, a little excess of care is by no means harmful, the research worker who has to get along without the assistance of a professional glass blower will be well advised to begin his attempts at glassworking by following the methods which the authors of this very readable volume have described with great clarity and care.

I. ESTERMANN

Office of Naval Research

Mathematical Analysis. A modern approach to advanced calculus. Tom M. Apostol. Addison-Wesley, Reading, Mass., 1957. xii + 553 pp. $8.50.

The viewpoint of this textbook is excellently summarized by its subtitle, "A modern approach to advanced calculus." The material is serious substantial mathematics; topics traditionally from advanced calculus are supplemented with extra background for function theory. The author states his aim to be a development which is "honest, rigorous, up-to-date, and . . . not too pedantic." As examples of the level of difficulty, functions of several variables are treated as functions of a vector, and integration theory is Riemann-Stieltjes. Each of the 16 chapters is concluded with a liberal supply of provocative, meaty exercises. Many of these significantly extend the theoretical development or provide meaningful examples and counterexamples; a few include hints for solution.

The style is unusually readable. Definitions, theorems, proofs, notes are clearly marked. Proofs are selected for brevity and forcefulness. The author displays a knack for breaking the development into proper sized bits for easy handling by the student. Many theorems are accompanied by a note explaining how the facet described in the theorem fits into the structure. The printing is superior, the proofreading almost flawless; the only error in content noted is in definition 8–16. This book is difficult for a weak class but should be thoroughly appreciated as a text for the strong students.

R. A. GOOD

University of Maryland

New Books

Urine and Urinary Sediment. A practical manual and atlas. Richard W. Lippman. Thomas, Springfield, Ill., ed. 2, 1957. 149 pp. $8.50.

Pre-Employment Disability Evaluation. Detailed policies regarding applicants applying for employment with special reference to various disabilities. William A. Kellogg. Thomas, Springfield, Ill., 1957. 170 pp. $10.50.

Applied Optics and Optical Design. A. E. Conrady. Dover, New York, 1957 (unabridged and corrected edition of ed. 1). 527 pp. $2.95.

Biochemistry of Some Peptide and Steroid Antibiotics. E. P. Abraham. Wiley, New York; Chapman & Hall, London, 1957. 107 pp. $3.

Clinical and Immunologic Aspects of Fungous Diseases. J. Walter Wilson. Thomas, Springfield, Ill., 1957. 299 pp. $6.75.

Practical Clinical Chemistry. A guide for technicians. Alma Hiller. Thomas, Springfield, Ill., 1957. 282 pp. $6.50.

Verbal Behavior. B. F. Skinner. Appleton-Century-Crofts, New York, 1957. 488 pp. $5.50.

The Tao of Science. An essay on Western knowledge and Eastern wisdom. R. G. H. Siu. Technology Press, Massachusetts Institute of Technology; Wiley, New York; Chapman & Hall, London, 1957. 196 pp. $4.25.

Year of Crisis. Communist propaganda activities in 1956. Evron M. Kirkpatrick, Ed. Macmillan, New York, 1957. 434 pp. $5.50.

General Zoology. Mary J. Guthrie and John M. Anderson, Wiley, New York; Chapman & Hall, London, 1957. 723 pp. $7.50.

Pleistocene Man at San Diego. George F. Carter. Johns Hopkins Press, Baltimore, 1957. 416 pp. $8.

Techniques of Magnetic Recording. Joel Tall. With chapter 7, "Recording Sound in Nature," by Peter Paul Kellogg. Macmillan, New York, 1958. 495 pp. $7.95.

Heat Transfer. vol. II. Max Jokob. Technical and editorial assistance by Stothe Peter Kezios. Wiley, New York; Chapman & Hall, London, 1957. 684 pp. $15.

Annual Review of Nuclear Science. vol. 7. James G. Beckerley, Ed. Annual Reviews, Palo Alto, Calif., 1957. 504 pp. $7.

Animal Behavior. John Paul Scott. University of Chicago Press, Chicago, 1958. 292 pp. $5.

Cortisone Therapy. Mainly applied to the rheumatic diseases. J. H. Glyn. Philosophical Library, New York, 1957. 172 pp. $10.

Geography in the Twentieth Century. A study of growth, fields, techniques, aims, and trends. Griffith Taylor, Ed. Philosophical Library, New York; Methuen, London, ed. 3, 1957. 685 pp. $10.

Long, Long Ago. Mary Lou Clark. Pageant Press, New York, 1957. 37 pp. $2.

Around the World in 90 Minutes. The fabulous true story of the man-made moons. David O. Woodbury. Harcourt, Brace, New York, 1958. 269 pp. $5.75.

Hypnography. A study in the therapeutic use of hypnotic painting. Ainslie Meares. Thomas, Springfield, Ill., 1957. 279 pp. $7.75.

Human Relations in Industrial Research Management. Including papers from the sixth and seventh annual conferences on industrial research, Columbia University, 1955 and 1956. Robert Teviot Livingston and Stanley H. Milberg, Eds. Columbia University Press, New York, 1957. 429 pp. $8.50.

Toward the Liberally Educated Executive. Robert A. Goldwin, Ed. Fund for Adult Education, White Plains, N.Y., 1957. 122 pp.

High-Talent Manpower for Science and Industry. An appraisal of policy at home and abroad. J. Douglas Brown and Frederick Harbison. Princeton University, Princeton, N.J., 1957, 95 pp. $3.

Nationalism in Colonial Africa. Thomas Hodgkin. New York University Press, New York, 1957. 216 pp. $3.75.

Solid State Physics. Advances in research and applications. vol. 5. Frederick Seitz and David Turnbull, Eds. Academic Press, New York, 1957. 470 pp. $11.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, *but to the publisher or agency sponsoring the publication.)*

Men, Steel, and Technical Change. Industrial Research Section, Department of Social Science, University of Liverpool. Department of Scientific and Industrial Research, London, 1957 (order from Her Majesty's Stationery Office). 36 pp. $0.36.

The Phylogeny and Classification of the North American Genera of the Suborder Tubulifera (Thysanoptera). Illinois Biological Monographs No. 25. Lewis J. Stannard, Jr. University of Illinois Press, Urbana, 1957. 200 pp. Paper, $2.50; cloth, $3.50.

Queensland Institute of Medical Research, Twelfth Annual Report of the Council of the Institute for the Year ended 30 June 1957. The Institute, Brisbane, Australia, 18 pp.

The Blood Lipids and the Clearing Factor. Third International Conference on Biochemical Problems of Lipids, 26–28 July 1956. Koninklijke Vlaamse Academie voor Wetenschappen, Letteren en Schone Kunsten van België, Brussels, Belgium, 1957. 418 pp.

Photography Through the Microscope. Kodak Publ. No. P-2. ed. 2. 72 pp. $0.75. *Abridged Scientific Publications from the Kodak Research Laboratories.* vol. XXXIII, 1951. 620 pp. Eastman Kodak Co., Rochester, N.Y., 1957.

Institute of Medical and Veterinary Science (South Australia), Eighteenth Annual Report of the Council, July 1955–June 1956. The Institute, Adelaide, Australia, 1957. 109 pp.

Agriculture and the Yearbook of Agriculture, 1849–1957. Office of Information, U.S. Department of Agriculture, Washington 25, 1957. 64 pp.

Looking Ahead in Fuels for Automotive Transportation. Society of Automotive Engineers, New York 17, 1957. 32 pp.

Meetings and Societies

Biologists Meet at Stanford

The first West Coast meeting of biological societies, under the sponsorship of the American Institute of Biological Sciences, was held at Stanford University, Palo Alto, California, 25–29 August 1957. At the same time and place the Pacific Division of the American Association for the Advancement of Science met. Thirty-six professional societies were officially represented, and 1600 research papers were read. Official registration was 3250, and total attendance exceeded 4000. Preceding the convention period and over the long September week-end following, ten extensive field trips were organized by various societies. One particularly hardy group transected California, camping in the high Sierra on the way. Another group collected intertidal marine algae at dawn on the beaches at Monterey. Horticulturalists took advantage of the nearby experiment stations and of the unusual agricultural areas of California. The 1957 exhibit was one of the largest ever held in connection with these annual meetings. Biologists showed a keen interest in the newly developed laboratory equipment and commercial products that were on display. Again this year the Biological Photographic Association exhibited a number of salon photographs of biological subjects. The AIBS Placement Service, available to all registrants at the convention, arranged interviews for four days.

The general AIBS meeting for all participating societies featured an address by H. Bentley Glass (Johns Hopkins University), retired president of the institute, on "The Responsibility of Biologists." Speaking to a capacity audience, Glass said: "Today we stand on the verge of biological discoveries of an equally revolutionary and potentially devastating kind, which will require all our wisdom to control. It is a frightening responsibility that rests upon us, as biologists, to see that these powers are used for good and not for harm." Speaking of the role of biologists in the community as a whole, Glass said: "I would feel no confidence in asking the profession of biology to take over the regulation of our government and our society. There are so few biologists who have gained anything like the required experience by entering into such public affairs as face citizens every day and everywhere. There are so few biologists who endeavor to make their biology count for anything outside the laboratory and the classroom." The speaker continued: "Our real social function as biologists, it seems to me, lies in education—the vast majority of our people have little understanding of science as a way of thinking or as a method of seeking answers to problems. . . . It must also be true that a nation with a microscopically few scientists molding and altering the lives of people and with a populace uncomprehending, superstitious, and resisting, likewise cannot endure. . . . My reasoning thus leads me back to the fundamental primary obligation of biologists as of all other scientists, the stern duty to teach—to spread as widely as possible among both young and old the comprehension of the bases of a scientific civilization." In conclusion, Glass stated: "We face new problems which are likely to become critical in the next years. The complete domination of scientific research by the holders of the purse strings is ominous, even though until now our foundations and government agencies have pursued policies of the most liberal kind. How long may that be expected to continue if the people and the representatives of the people feel that science is a useful servant or slave to minister to the needs of society as bidden?"

The annual meeting of the Pacific Division of the AAAS featured a presidential address by J. Murray Luck (Stanford University), "Man against His Environment: the Next Hundred Years" [*Science* **216**, 903 (1957)].

The subjects of radiation and fallout hazards occupied a considerable portion of everyone's discussions and were covered in numerous papers. Several symposia offered the latest data on fallout, the ecological aspects of the situation, and the dangers of strontium-90 and the absorption of this element by man, plant, and animal. Of the many papers presented, probably one of the most significant was that offered by Michael A. Bender (Johns Hopkins University). Bender's experiments gave sharp indication that the 10-roentgen maximum permissible average dose of radiation (to the reproductive organs from conception to age 30) given in the report by the National Academy of Sciences may be too high. Bender for the first time submitted normal human cells to known doses of radiation and measured the amount of resulting damage. In cells examined two days after irradiation, 25 roentgens of x-rays had produced roughly six chromosome breaks per 100 cells, and 50 roentgens had produced more than double this number. Bender reported, "The breakage rate found in these experiments is much higher than that which has been generally assumed to occur for such low dosage. In fact, the present experiments, taken by themselves, lend great weight to the belief of many geneticists that there is no safe dose of radiation."

In contrast, a group from the Argonne National Laboratory (M. P. Finkel, B. O. Biskis, and G. M. Scribner), using mice, estimated the biological hazards of strontium-90. At high doses the mice died of acute and subacute irradiation disease. At intermediate doses there were many lymphoid tumors. As the dose decreased the death rate and cancer rate decreased. In the low dose areas the most sensitive measure of effect thus far seen has been the reduction in life span. The threshold for this effect appears to be an injected dose of 0.23 micromicrocurie per gram of mouse, or a retained dose of approximately 0.03 micromicrocurie per gram of mouse. If a direct comparison is made to man—and there are many sources of error in such comparisons—this corresponds roughly to twice the maximum permissible level in man and to 1000 times the most pessimistic estimate of current human contamination from fallout.

H. Boroughs, S. Townsley, and W. Ego (University of Hawaii Marine Laboratory) found that the small shrimp *Artemia*, a common and abundant fish food, became radioactive after it was placed in sea water which contained strontium-90. However, most of the radioactivity was due to yttrium rather than to strontium; only about 2 percent of the radioactivity came from the strontium-90. If other shrimplike animals select yttrium over strontium, it may be that marine fish do not become nearly as radioactive as is believed. Unfortunately, it is also known that other animals in the sea do concentrate radiostrontium and that these animals are in turn used as food by fish, and therefore by man.

Using amoebae, E. W. Daniels and H. H. Vogel, Jr. (Argonne National Laboratory) obtained interesting information on how to prevent the death of lethally irradiated animals. Following

two continual lethal doses of fission neutrons, protoplasm in varying amounts was transferred from nonirradiated amoebae to the irradiated cells. Ninety-one percent of the amoebae thus treated survived for the period of experimental study. Most of the cells that lived were capable of giving rise to large cultures of offspring. In an effort to determine which parts or components of the protoplasm were necessary for recovery, nonirradiated cells were centrifuged, and the light and heavy portions of their protoplasm were separated. It was found that the middle and centrifugal (heavy) thirds are about as effective in preventing death as whole, noncentrifuged protoplasm.

Lauren R. Donaldson (University of Washington Applied Fisheries Laboratory), told biologists of work carried out in the Pacific Ocean to trace the dispersion of fallout radioactivity. After the detonations in June 1956 at the Pacific Proving Ground, an area of 78,000 square miles of ocean immediately surrounding Bikini and Eniwetok atolls was outlined as radioactive. In September a second survey trip was made. By then radioactive decay and dilution had greatly lowered the activity. But the slow movement of the tagged water mass had put the fringes of radioactivity some hundreds of miles farther westward. In September the average ratio of activity in plankton to activity in sea water was found to be 2500 to 1. It was apparent that the plankton was controlling the westward drift of radioactivity. At this time, too, it was noted that there were differences in the isotopic content of plankton samples collected north of Eniwetok and those collected 500 miles to the west. One of the unique findings was that nonfission products rather than the radioactive products of the nuclear fission accounted for the major parts of the long-lived residual radiation. These nonfission products were radioactive iron, manganese, cobalt, and zinc. In some instances the nonfission products produced 90 to 100 percent of the radiation detectable in the samples.

In the long battle against plant diseases, a possible means of preventing virus infection was announced by T. C. Allen, Jr., and R. P. Kahn (Army Chemical Corps Biological Warfare Laboratories). Extracts from rice plants were found to inhibit the growth of several plant viruses. Several different parts of several rice varieties were used, notably rice "juice" from crushed leaves, and rice polish, the by-product remaining after rice kernels are milled. Rice polish, in general, proved to be the most effective of all extracts. It did not seem to matter whether the polish was applied before or immediately after inoculation of the virus. Tobacco mosaic virus, common bean mosaic virus, tobacco necrosis virus and Southern bean mosaic virus and pod mottle virus were used in the experiments. The results were uniformly good, and in several cases 100 percent inhibition resulted. Rice polish seemed to exert an immunizing or chemotherapeutic effect. Its use may offer a more rapid approach to control than the present practice of developing disease-resistant strains of plants.

Emil Witschi (State University of Iowa) reported that he has been able to distinguish between male and female embryos as early as the third week of development. Witschi used a modification of the sex chromatin technique of M. Barr, Canadian neurologist, who found male and female patterns among the stainable granules of the nuclei of the large cells of the embryonic heart. At the same time, Witschi reported that sex reversals are known to occur occasionally in human embryos during the early weeks of pregnancy. Instrumental in such reversals are degenerative changes in the germ cell from various causes—for example, overripeness of the egg at fertilization.

An interchange of many land mammals, including man, doubtless took place over a land bridge between the North American and Asiatic continents during Quaternary and Tertiary times, reported W. H. Burt (University of Michigan). Over one-half of the land mammals of western North America have close relatives in Asia, and some northern mammals are circumpolar in distribution. Examples of these are the gray wolf, arctic fox, brown bear, ermine, least weasel, wolverine, arctic ground squirrel, moose, caribou, and some of the small shrews, voles, and lemmings. The Eskimo may also be included in this category. Among the North American mammals that failed to cross the land bridge are kangaroo rats, pocket mice, pocket gophers, and pronghorn antelopes. These mammals had their origin in western North America and have remained there to this day. The Asian counterparts are the carnivores known as civets and jerboas. Burt believes that, since these animals all inhabit semiarid areas, the land connection that existed between the two continents was probably not sufficiently arid for a long enough period of time to attract them.

A. D. Hasler, T. Schreiner, and W. Braemer (University of Wisconsin) have trained fish to find food and a hiding place in a given compass direction irrespective of the position of the sun in its path across the sky. Fish tagged at their spawning ground and released 2 miles away returned to the spawning sites in less than 24 hours in spite of the high turbidity of the water and their inability to see the shore or the bottom. On cloudy days, however, the displaced fish distributed themselves irregularly. If the fish were blinded with eye caps, their movements were slowed down and they drifted aimlessly with the currents. In the laboratory the fish were found to orient themselves to an artificial sun.

It has been observed many times that alfalfa does not establish itself on newly plowed sod infested with quack grass. Attempting to solve this dilemma, T. Kommedahl, A. J. Linck, and J. V. Bernardini (University of Minnesota) used ground rhizomes of quack grass that had been dried, sterilized to kill microorganisms, and then mixed with soil. Alfalfa grown in such mixtures was stunted and often yellow. Top growth was 65 percent less than that of alfalfa grown in pots with ordinary soil. Water extracts from rhizomes were also tested, and the result was a 60 percent reduction in top growth. Indications are that the quack grass produces a toxic substance or substances not yet identified.

Contradicting in part commonly held beliefs that life span depends on metabolism, G. A. Sacher (Argonne National Laboratory) offered evidence of a relationship between brain weight and maximum life span. Sacher suggested that if two species of animals differ in their ability to regulate, other things being equal, the species with the better regulation should have the greater life span. This would tend to account for man's longer length of life, for man should have better regulatory mechanisms than most lower animals have. Basing his considerations on the fact that the complexity and precision of regulatory mechanisms would be reflected in the sheer size or weight of the brain, Sacher used brain weight to measure indirectly the ability to regulate. His expectations have been confirmed for 60 species of mammals tested to date.

S. Zamenhof, R. de Giovanni, and S. Greer (Columbia University), working with sewage bacteria, substituted artificially prepared 5-bromouracil for thymine. The man-made molecule was incorporated into the bacteria's deoxyribonucleic acid, the basic substance of genes. As much as one-half of the bacteria's thymine was replaced by the 5-bromouracil. The bacteria with "bogus" genes differed in many ways from the original strain. Some were dwarfs, others giants, and many had lost their ability to manufacture certain essential enzymes. Even when all the 5-bromouracil was withdrawn from the media, some of the organisms retained the grotesque characteristics. In some experiments three or more of every 100 cells mutated. Some of the mutants have now persisted through 180 generations in the absence of 5-bromouracil and can be regarded as stable mutant strains.

These experiments may offer an explanation for the facts that some infectious bacteria survive antibiotics and some cancer cells resist anticancer drugs.

In the very few years since gibberellic acid was discovered, a large body of literature has accumulated. Several scores of papers on this subject were presented during the Stanford meetings. B. O. Phinney, one of the pioneers in the work, and P. M. Neely reported on the use of the mutant dwarf-1 of maize as a quantitative bioassay for gibberellin activity. The amount of response in the dwarf corn is in relation to the amount of material added. This response is specific to gibberellic acid and similar compounds. No other known plant growth regulators produce such response. The assay is quite sensitive, amounts down to 0.0001 microgram per plant being detectible. The assay has been used to estimate the difference in activity between gibberellic acid and gibberellin A, to determine the movement of gibberellins in plant tissues, and to determine the amounts of gibberellinlike substances produced by flowering plants.

L. V. Barton and J. M. Fine (Boyce Thompson Institute for Plant Research) reported on the spreading use of gibberellic acid in combination with pesticides. No interference seems to take place. The use of gibberellic acid in commercial potato production was discussed by L. Rappaport, H. Timm, and L. Lippert (University of California, Davis). A 5-minute bath in a gibberellin solution breaks the usual rest period of potatoes and brings on sprouting one to two weeks early. Recent experiments have shown that application of gibberellin sprays to plant foliage as long as seven weeks before harvest can also break the dormancy.

C. Chandler (Boyce Thompson Institute for Plant Research) discussed the use of gibberellic acid in pollen germination and the effect on pollen-tube growth. Production of desirable hybrids is often impossible because of the failure of pollen to germinate or grow fast enough to effect fertilization before the flowers drop. The percentage of germination of some plants tested was increased two to three times. Pollen-tube length was increased one to five times with the use of gibberellic acid. However, not all plants responded to gibberellic acid, and it is suggested that individual species be tested before application.

Blood-grouping studies in cattle have been under way since 1940, and in that short period of time more has been learned about these groups than for any other species, including man. W. J. Miller and C. Stormont (University of California, Davis) reported on parentage exclusion by blood-grouping studies in cattle. A dozen different systems of blood groups have been discovered, and it is calculated that over 400 billion blood types are possible in cattle. Ninety-five percent of all parentage problem testing done in the laboratory at Davis has been successful. In other words, a positive answer can be given in 19 of 20 cases when it is necessary to decide which of two bulls is qualified as the sire of a given calf.

The ergot alkaloids produced by the fungus *Claviceps purpurea*, used in childbirth and in the treatment of migraine headaches, are at the present time produced only in Europe. Only two laboratories have been successful in growing the fungus in liquid culture media, and they are located overseas. W. A. Taber and L. C. Vining (National Research Council of Canada, Saskatoon) have now reported on a method for the production of the alkaloids. Only certain strains of the fungus were found capable of synthesizing the alkaloids under laboratory conditions, and certain sugars and nitrogen compounds were found necessary for growth. Unexpectedly, illumination was found to increase alkaloid production significantly.

ILEEN E. STEWART
American Institute of Biological Sciences, Washington, D.C.

Comparative Endocrinology

A symposium on Comparative Endocrinology, sponsored by Columbia University, has been scheduled for the period 26–29 May at Cold Spring Harbor, N.Y. Because of the limited housing accommodations, advance registration is recommended. For information concerning the program write to: Symposium on Comparative Endocrinology, Department of Zoology, Columbia University, New York 27, N.Y.

Pulmonary Circulation

The Chicago Heart Association is sponsoring a conference on pulmonary circulation that is to be held 20–22 March at the Palmer House. Introductory sessions will be devoted to the physiology, anatomy, and pathology of pulmonary circulation, with special emphasis on methods of clinical study. Later sessions will cover pulmonary circulation in congenital heart disease, primary lung disease, and acquired heart disease.

Among the visitors who are accepting major responsibility in the planning and execution of the conference are Julius Comroe of the University of Pennsylvania Graduate School of Medicine; Howard Burchell and Jesse Edwards of the Mayo Clinic, Rochester, Minn.; Paul Wood, from the Institute of Cardiology, London; and Lars Werko of Goteborgs Universitet, Gothenburg, Sweden. For information, write to Dr. Wright Adams, Chicago Heart Association, 69 W. Washington St., Chicago 2, Ill.

Forthcoming Events

March

1. Junior Solar Symposium, Tempe, Ariz. (Association for Applied Solar Energy, 3424 N. Central Ave., Phoenix, Ariz.)

1–3. National Wildlife Federation, St. Louis, Mo. (E. F. Swift, NWF, 232 Carroll St., NW, Washington 12.)

3. Wildlife Soc., annual, St. Louis, Mo. (D. L. Leedy, U.S. Fish and Wildlife Service, Washington 25.)

5–6. Gas Conditioning Conf., 7th annual, Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

6–8. Fundamental Cancer Research, 12th annual, Houston, Tex. (W. K. Sinclair, M. D. Anderson Hospital and Tumor Inst., Univ. of Texas, Houston 25.)

9–14. International College of Surgeons, 11th biennial cong., Los Angeles, Calif. (K. A. Meyer, 1516 Lake Shore Dr., Chicago 10, Ill.)

10–13. American Assoc. of Petroleum Geologists, annual, Los Angeles, Calif. (R. H. Dott, AAPG, Box 979, Tulsa 1, Okla.)

10–13. Society of Economic Paleontologists and Mineralogists, annual, Los Angeles, Calif. (R. H. Dott, Box 979, Tulsa, Okla.)

16–21. Nuclear Engineering and Science Cong., Chicago, Ill. (D. I. Cooper, *Nucleonics*, 330 W. 42 St., New York.)

17–21. National Assoc. of Corrosion Engineers, 14th annual, San Francisco, Calif. (NACE, Southern Standard Bldg., Houston 2, Tex.)

18–20. Amino Acids and Peptides, Ciba Foundation symp. (by invitation), London, England. (G. E. W. Wolstenholme, 41 Portland Pl., London, W.1.)

20–22. Michigan Acad. of Science, Arts and Letters, annual, Ann Arbor. (R. F. Haugh, Dept. of English, Univ. of Michigan, Ann Arbor.)

20–22. Pulmonary Circulation Conf., Chicago, Ill. (Wright Adams, Chicago Heart Assoc., 69 W. Washington St., Chicago 2.)

20–23. International Assoc. for Dental Research, annual, Detroit, Mich. (D. Y. Burrill, Northwestern Univ. Dental School, 311 E. Chicago Ave., Chicago, Ill.)

23–26. American Assoc. of Dental Schools, annual, Detroit, Mich. (M. W. McCrea, 42 S. Greene St., Baltimore 1, Md.)

23–29. American Soc. of Photogrammetry, 24th annual, jointly with American Cong. on Surveying and Mapping, 18th annual, Washington, D.C. (C. E. Palmer, ASP, 1515 Massachusetts Ave., NW, Washington 5.)

24–26. Aero Medical Assoc., 29th an-

nual, Washington, D.C. (T. H. Sutherland, Box 26, Marion, Ohio.)

24–27. Institute of Radio Engineers, natl. conv., New York. (G. W. Bailey, IRE, 1 E. 79 St., New York 21.)

26–28. American Power Conf., 20th annual, Chicago, Ill. (Illinois Inst. of Technology, 35 W. 33 St., Chicago 16.)

27–29. American Physical Soc., Chicago, Ill. (E. R. Fitzgerald, Dept. of Physics, Pennsylvania State Univ., University Park.)

27–29. Mechanisms of Hypersensitivity, 8th internatl. symp., Detroit, Mich. (W. J. Nungester, Dept. of Bacteriology, Univ. of Michigan, Ann Arbor.)

27–29. National Science Teachers Assoc., 6th natl., Denver, Colo. (R. H. Carleton, NSTA, 1201 16 St., NW, Washington 6.)

27–29. Optical Soc. of America, Washington, D.C. (S. S. Ballard, Scripps Institution of Oceanography, San Diego 52, Calif.)

29. South Carolina Acad. of Science, annual, Charleston. (Miss M. Hess, Dept. of Biology, Winthrop College, Clemson, S.C.)

29–30. American Psychosomatic Soc., 15th annual, Cincinnati, Ohio. (T. Lidz, 551 Madison Ave., New York 22.)

30–3. American College Personnel Assoc., annual, St. Louis, Mo. (L. Riggs, DePauw Univ., Greencastle, Ind.)

April

1. Microcirculatory Conf., 5th, Buffalo, N.Y. (S. R. M. Reynolds, Dept. of Anatomy, Univ. of Illinois College of Medicine, 1853 W. Polk St., Chicago 12.)

1–3. Corrosion Control, 5th annual conf., Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

2–4. American Assoc. of Anatomists, annual, Buffalo, N.Y. (L. B. Flexner, Dept. of Anatomy, School of Medicine, Univ. of Pennsylvania, Philadelphia 4.)

2–4. Instruments and Regulators Conf., Newark, Del. (W. E. Vannah, Control Engineering, 330 W. 42 St., New York 36.)

3–5. Pennsylvania Acad. of Science, annual, Easton, Pa. (G. R. Stevens, Dept. of Geology and Geography, Lafayette College, Easton.)

4–5. Southern Soc. for Philosophy and Psychology, annual, Nashville, Tenn. (W. B. Webb, U.S. Naval School of Aviation Medicine, Pensacola, Fla.)

7–11. American Assoc. of Cereal Chemists, annual, Cincinnati, Ohio. (J. W. Pence, Western Utilization Research Laboratories, Albany, Calif.)

8–10. Electronic Waveguides Symp., New York. (J. Fox, Microwave Research Inst., Polytechnic Inst. of Brooklyn, 55 Johnson St., Brooklyn 1, N.Y.)

9–12. National Council of Teachers of Mathematics, Cleveland, Ohio. (M. H. Ahrendt, NCTM, 1201 16 St., NW, Washington 6.)

9–14. Applied Psychology, 13th internatl. cong., Rome, Italy. (L. Meschieri, National Inst. of Psychology, Rome.)

10–11. American Inst. of Chemists, annual, Los Angeles, Calif. (L. Van Doren, AIC, 60 E. 42 St., New York 17.)

10–12. Biometric Soc., ENAR, Gatlinburg, Tenn. (T. W. Horner, General Mills, Inc., 400 Second Ave. South, Minneapolis 1, Minn.)

10–12. National Speleological Soc., annual, Gatlinburg, Tenn. (G. W. Moore, Geology Dept., Yale Univ., New Haven, Conn.)

10–12. Ohio Acad. of Science, annual, Akron, Ohio. (G. W. Burns, Dept. of Botany, Ohio Wesleyan Univ., Delaware.

11. Vitamin B-12 Symp., New York, N.Y. (Miss J. Watson, 451 Clarkson Ave., Brooklyn 3, N.Y.)

11–12. Eastern Psychological Assoc., annual, Philadelphia, Pa. (G. Lane, Dept. of Psychology, University of Delaware, Newark.)

11–18. Horticultural Cong., 15th internatl., Nice, France. (Secretariat General, 84, rue de Grenelle, Paris 7e, France.)

13–14. American Soc. for Artificial Internal Organs, Philadelphia, Pa. (G. Schreiner, Georgetown Univ. Hospital, Washington 7.)

13–18. American Chemical Soc., 133rd, San Francisco, Calif. (R. M. Warren, ACS, 1155 16 St., NW, Washington 6.)

13–19. Federation of American Societies for Experimental Biology, annual, Philadelphia, Pa. (M. O. Lee, FASEB, 9650 Wisconsin Ave., Bethesda 14, Md.)

14–16. Automatic Techniques Conf. Detroit, Mich. (J. E. Eiselein, RCA, Bldg. 10–7, Camden 2, N.J.)

14–18. American Assoc. of Immunologists, annual, Philadelphia, Pa. (F. S. Cheever, Graduate School of Public Health, Univ. of Pittsburgh, Pittsburgh 13, Pa.)

14–18. American Soc. for Experimental Biology, annual, Philadelphia, Pa. (J. F. A. McManus, Univ. of Alabama Medical Center, Birmingham.)

14–18. American Soc. of Biological Chemists, annual, Philadelphia, Pa. (P. Handler, Dept. of Biochemistry, Duke University School of Medicine, Durham, N.C.)

15–17. Gas Measurement, 34th annual conf., Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

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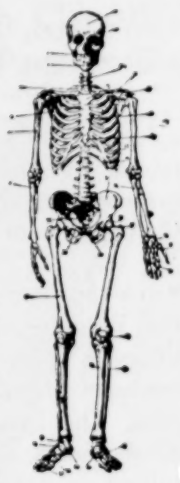

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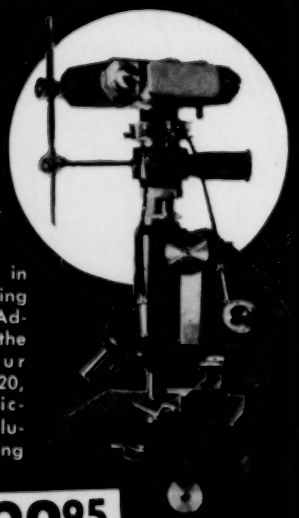

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LETTERS

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Symbols to Indicate Castration

Symbols and abbreviations are used by most scientists and researchers when recording or describing the result of some observation or experiment.

Symbols denoting the sexes of animals (♂ ♀) have been used for many many years. There is nothing about these symbols, however, to indicate whether the animal is sexually intact and in possession of its gonads or whether it is a castrate. The importance of indicating the difference may be very great at times.

It is proposed that the circle part of the symbol be opened in the case of castrates to form the letter C. The arrow and cross-piece characteristic of the male and female, respectively, would have their regular position on the circle.

H. C. H. KERNKAMP
College of Veterinary Medicine, University of Minnesota, St. Paul

"Weaver Finch"

Mayr, Linsley, and Usinger [*Methods and Principles of Systematic Zoology* (1953), p. 17] state: "Even the experimental biologist has learned to appreciate the necessity for sound, solid identification. There are great numbers of genera with two, three, or more very similar species. Such species very often differ more conspicuously in their physiological traits than in their morphological characters."

This statement seems so obvious to most taxonomists as to make its repetition verge on the flogging of a dead horse. Hence it was all the more surprising and disappointing to find the paper by S. J. Segal in the December 13 issue of *Science* [*Science* **126**, 1242 (1957)] describing certain hormonal experiments on "the weaver finch." Taxonomists have more or less resigned themselves to seeing generalizations in the literature of such disciplines as physiology, endocrinology, and embryology about *the* duck, *the* goose, *the* pigeon, *the* rat, or *the* rabbit; it can be reasonably assumed that the experimental animal in such cases is the common domesticated species (although I believe it should be explicitly so stated). However, "*the* weaver finch" is completely meaningless. "Weaver finch" is a general

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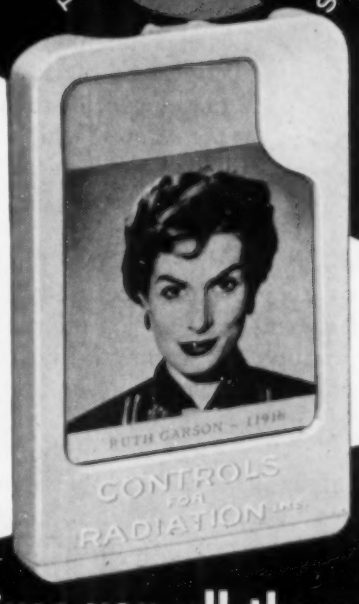

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term applied to many of the members of a very large bird family, Ploceidae, which may even be of polyphyletic origin. No more precise name than "weaver finch" is given, either in English or in Latin, in Segal's paper. It might be argued that reference can be made to earlier papers cited; this is true, although it should not be necessary. Checking one of Segal's cited references, that to Witschi's paper in *The Wilson Bulletin,* I find no less than four species of the family Ploceidae mentioned: the English sparrow (*Passer domesticus*), the paradise whydah (*Steganura paradisaea*), the red-billed weaver (*Quelea quelea*), and the orange weaver (*Euplectes orix*). Scientific names are given by Witschi for the last two only. The brief description given by Segal of his experimental birds ("the male bird assumes a bright yellow and black plumage . . .") fits none of the species mentioned by Witschi; the *Euplectes,* which comes closest, is described by Witschi as "black and orange red."

Segal's experimental bird is not identifiable from his description as published. In any case, it is almost certainly a member of a genus of the sort mentioned in the quotation from Mayr, Linsley, and Usinger, "with two, three, or more very similar species"—there are many such genera in the Ploceidae. The normal cycle of molts and plumages in wild birds may vary, even among closely related species, to the extent that it should be considered of fundamental importance to establish the identity of the experimental birds.

One further point. Segal mentions his "weaver finch" as being "readily available in the United States because large numbers are imported for sale to bird fanciers." Having had experience in recent years for the identification for zoos and aviaries of birds sold by importers, I would consider such birds to be extremely unreliable as standardized experimental animals. Birds of several genera are sold under the general term "weaver birds." A dealer may supply two shipments of what he honestly believes to be the same species to the experimenter; unfortunately, neither may be capable of recognizing the differences between closely-related species in a genus such as *Ploceus,* one of the largest genera of weavers; the consecutive shipments may well involve more than one species. Even *within* a single species the possibility arises of geographic variation in physiological characteristics, a well-known phenomenon in certain groups of birds and other animals. Very few importers of cage birds have any notion as to the precise area of Africa from which their weaver birds may be derived.

In the absence of an established breeding stock of experimental animals such as is now available for the golden hamster or the budgerigar, it would appear to be of critical importance for nontaxonomic zoologists to secure authoritative taxonomic identifications of their subjects before publication of their results.

KENNETH C. PARKES
Carnegie Museum,
Pittsburgh, Pennsylvania

I shall humbly agree that, in my description of "the weaver finch," it might have been pointed out more clearly that the so-called "yellow weaver" or "Napoleon weaver" (*Euplectes afra*) is the species that serves in the establishment of the standard of the discussed hormonal reaction.

In all other respects the criticisms of Parkes seem misdirected. Before writing a letter to the editor, he might have consulted not only the oldest but also the most recent summary by Witschi (reference *3* of my report). He would have found color photographs, of various species and reactions, adequate to satisfy anyone more particularly interested in the taxonomic and technical aspects of the feather reaction. He might then, also, have followed a reference to a readily available paper [E. Witschi, *Endocrinology* **27**, 437 (1940)] in which *weaver finch test* and *weaver finch unit* are introduced as technical terms. In accordance with good usage, these terms are clearly defined, and the reactions of *E. afra* are compared with those of several other species.

It should be evident to all readers that my short report in *Science* of 13 Dec. 1957 was meant to be a contribution to endocrine physiology. Taxonomic considerations do not necessarily enter into the discussion of assay materials such as I have presented. All data refer to a single species. Moreover, each individual bird serves as its own control. The positive or negative reaction of a bar across a single regenerated feather is always compared with the tip and the base which grew before and after injected hormone substances were present in the systemic circulation. With this I do not deny that taxonomic and physiologic variation in plumage characters of finches is a subject of interest. Publication of a large assemblage of data that I have collected in Iowa City over more than twenty-five years is, in fact, in preparation.

Regarding the quotation from Mayr, Linsley, and Usinger, there can be little doubt but that these three experts mean exactly what they say: namely, that the experimental biologists *have* learned to appreciate physiologic traits and differences. If "most taxonomists" are wise to it as well, for whom, Dr. Parkes, was their message intended?

SHELDON J. SEGAL
The Population Council, Inc.,
Rockefeller Institute, New York

EQUIPMENT NEWS

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science does not assume responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to Science, *Room 740, 11 W. 42 St., New York 36, N.Y. Include the name(s) of the manufacturer(s) and the department number(s).*

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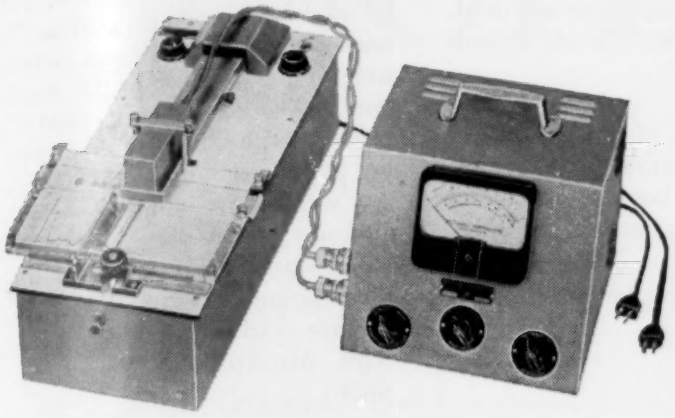

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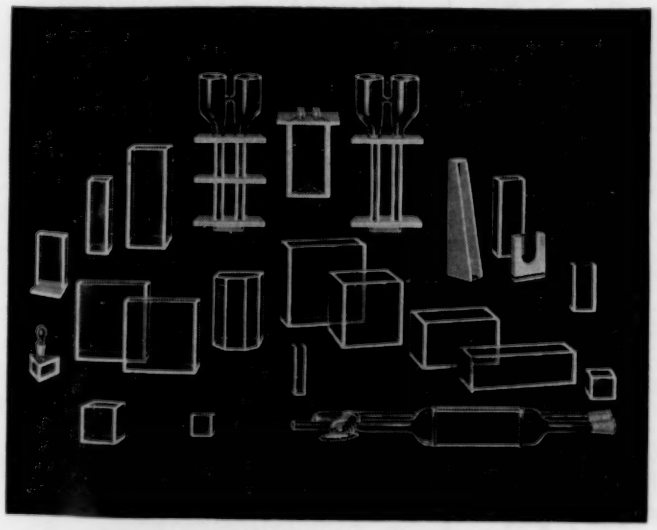

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